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INTRODUCTION

Relationships of animals and plants are determined in three ways: (1) By palaeontology, or the succession of fossil forms, the earlier being the ancestors of the later; (2) by morphology, or similarities and differences of form; (3) by embryology, or the development of the individual from the embryo, such development being supposed to recapitulate more or less accurately the evolution of the species.

Where all three methods are available a high degree of certainty may be attained. There can be no doubt that birds came from reptiles, for (1) palaeontology shows that reptiles preceded birds in point of time and that the first birds had reptilian tails and teeth, (2) morphology shows that the structure of birds is only a modified form of the reptilian, and (3) embryology shows that the young bird in its development from the egg passes through a reptilian stage.

By such methods of research the main outlines of evolution have been thoroughly established, but within the outlines there is an infinity of detail which has never been studied thoroughly, or at all, and of which all that can be said is that this probably came from that, though it may turn out that it came from something else.. It is certain that birds in general came from reptiles, but it is not so certain that canaries came from starlings. Again, language must not be interpreted too literally. When it is said that canaries came from starlings it is meant that they came from the starling group.

All that is attempted in this series of diagrams is to set forth the opinions of specialists as they have been gathered, a little here and a little there, from technical publications, and in some instances from specialists themselves, for whose assistance I am very grateful.

Scientific names are derived mostly from the Greek and Latin and should be pronounced as they are in dictionaries, that is, according to the English method of pronouncing Latin (not the Roman method used in schools). The acute accent (é) indicates the short, and the grave accent (è) the long sound of the vowel in the accented syllable. In case of diphthongs the accent is placed over the second vowel.

In Latin words there are as many syllables as there are vowels and diphthongs—one syllable for each:

Primates—Pri-ma-teez (Firsts).
Peristeropodes—Per-is-ter-op-o-deez (Pigeon-footed).
Asteroides—As-ter-o-eye-deez (Star-like).
Rosales—Ro-za-leez (Rose order).
Rosaceae—Ro-za-see-ee (Rose family).
Bovidae—Bo-vi-dee (Ox family).

Names of families in botany end in **-aceae**, names of orders in **-ales**. In zoology family names end in **-idae**; names of orders irregular. An order is composed of a group of families, though some have but one, the others perhaps being extinct.

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TIME-TABLE OF THE EARTH

Rivers constantly carry down mud in solution, depositing it in the quiet waters near their mouths, where it settles to the bottom. Even in the middle of the ocean there is a gradual accumulation of the remains of the life of the sea. In this manner the strata constituting the earth's crust have been formed. The deposits of one period, containing remains of the life of that period, cover the deposits of a previous period. Estimating one foot of deposit per century, it is about 25,000,000 years since the beginning of the Cambrian period, at which time three-fourths of the evolution that has taken place in the world had already been accomplished. Assuming again that evolution proceeds at a fairly uniform rate, it is 100,000,000 years since the beginning of life on the earth. In the following table the times relate to the beginnings of the respective periods:

	Years
CENOZOIC	
(2) Quaternary	
RECENT—Incalculable, but probably	50,000
PLEISTOCENE (Glacial period)	400,000
(1) Tertiary	
PLIOCENE	1,700,000
MIOCENE	3,100,000
OLIGOCENE	4,300,000
EOCENE	6,300,000
MESOZOIC	
CRETACEOUS (Upper Cretaceous)	8,700,000
COMANCHEAN (Lower Cretaceous)	10,700,000
JURASSIC	11,500,000
TRIASSIC	13,200,000
PALAEOZOIC	
PERMIAN	14,400,000
CARBONIFEROUS (Pennsylvanian and Mississippian)	17,300,000
DEVONIAN	19,500,000
SILURIAN (Upper Silurian)	21,000,000
ORDOVICIAN (Lower Silurian)	22,700,000
CAMBRIAN	25,300,000
PROTEROZOIC	
KEWEENAWAN	30,300,000
ANIMIKIAN	31,700,000
HURONIAN	33,500,000
ARCHAEOZOIC	
ARCHAEAN (Laurentian, etc.)	100,000,000

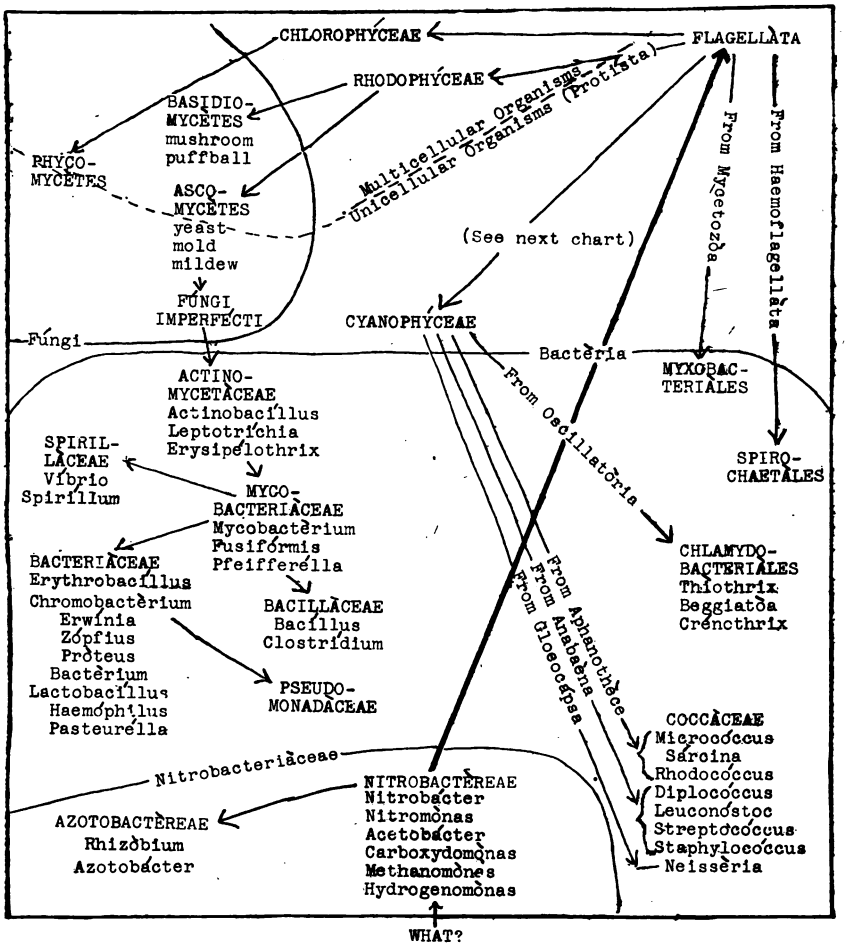

Diagram 1. BACTERIA (Little rods), as the causes of disease, are popularly known as "germs" and "microbes." Many are in the form of little rods, often provided with flagella (whips), some are globular and known as cocci (pronounced cock-eye), which means berries, and some are in chains (Streptococci), or bunches of grapes (Staphylococci). All are very minute, and some are so small that a million could stand on the head of a pin without touching one another. Even the giant bacterium, Hillhousia mirabilis, is invisible to the naked eye.

One group of bacteria, set apart from all the rest by their ability to live on inorganic matter, are regarded as the lowest known forms of life. As higher forms developed the higher could eat the lower and the lower could prey on the higher, but the very first must have lived on inorganic matter.

At the bottom of the known forms of life stands Hydrogenomonas pantotropha (All-nourishing hydrogen unit), which is capable of securing growth energy by the oxidation of hydrogen, the name implying that it is the foundation of all life, which is probably not quite true, since, theoretically, there must have been forms still lower.

From this first group of bacteria probably came Rhizobium leguminosarum (Living on roots of legumes), which fixes nitrogen on the roots of clover and alfalfa, enriching the soil.

Other groups of bacteria are degenerate forms of algae, fungi, and protozoa. After advancing to the flagellate and algae stages they lost what they had gained and fell back into their old class, but on account of their experiences on the way they could never be the same kind of bacteria they were before. It is only these degenerate bacteria that produce diseases. And not all of these, for many are harmless and even beneficial to man.

Actinomycetales.

Actinomyces bovis—causes lumpjaw in cattle.
Actinomyces scabies—potato scab.
Mycobacterium tuberculosis—tuberculosis.
Corynebacterium diphtheriae (Klebs-Loeffler bacillus)—diphtheria.
Pfeifferella mallei—glanders.

Spirillaceae.

Vibrio comma—Asiatic cholera.

Bacteriaceae.

Erwinia amylovora—pear blight.
Erwinia solanacearum—brown rot of tomato, egg plant, and potato.
Bacterium coli—in human intestines, but probably harmless.
Bacterium cholera-suis and B. suipestifer—hog cholera and swine plague (relationships obscure).
Bacterium dysenteriae—bacterial dysentery (the other kind being caused by an amoeba).
Bacterium typhosum—typhoid fever.
Lactobacillus—sours milk.
Haemophilus influenzae—influenza ("grip," "flu").
Haemophilus pertussis—whooping cough.
Pasteurella cholera-gallinarum—chicken cholera.
Pasteurella pestis—bubonic plague ("black death" of the Middle Ages).

Bacillaceae.

Bacillus anthracis—anthrax or splenic fever.
Clostridium tetani—lockjaw.
Clostridium feseri—symptomatic anthrax in cattle and sheep.

Pseudomonadaceae.

Pseudomonas campestris—black rot of cabbage.

Coccaceae.

Diplococcus pneumoniae—pneumonia.
Streptococcus erysipelatos—erysipelas.
Staphylococcus pyogenes aureus—abscesses, pustules, and boils.
Neisseria gonorrhoeae—gonorrhoea.
Micrococcus meningitidis—cerebro-spinal meningitis.

Chlamydobacteriales.

Crenothrix polyspora—imparts bad taste to water in ponds and reservoirs and chokes tubular wells with deposits of iron.
Thiothrix nivea—in hot sulphur springs.
Beggiatoa alba—in hot sulphur springs.

Spirochaetales.

Spirochaeta obermeieri—relapsing fever.

Bacteria are also the oldest known form of life, fossil bacteria having been discovered in the Laurentian rocks of Montana of the estimated age of over 33,000,000 years.

An English bishop suggests that the demons that were cast out in New Testament times, whose name was "Legion" (Mark v. 9; Luke viii. 30), were bacteria, but strangely omits to explain how plants learned to talk Greek!

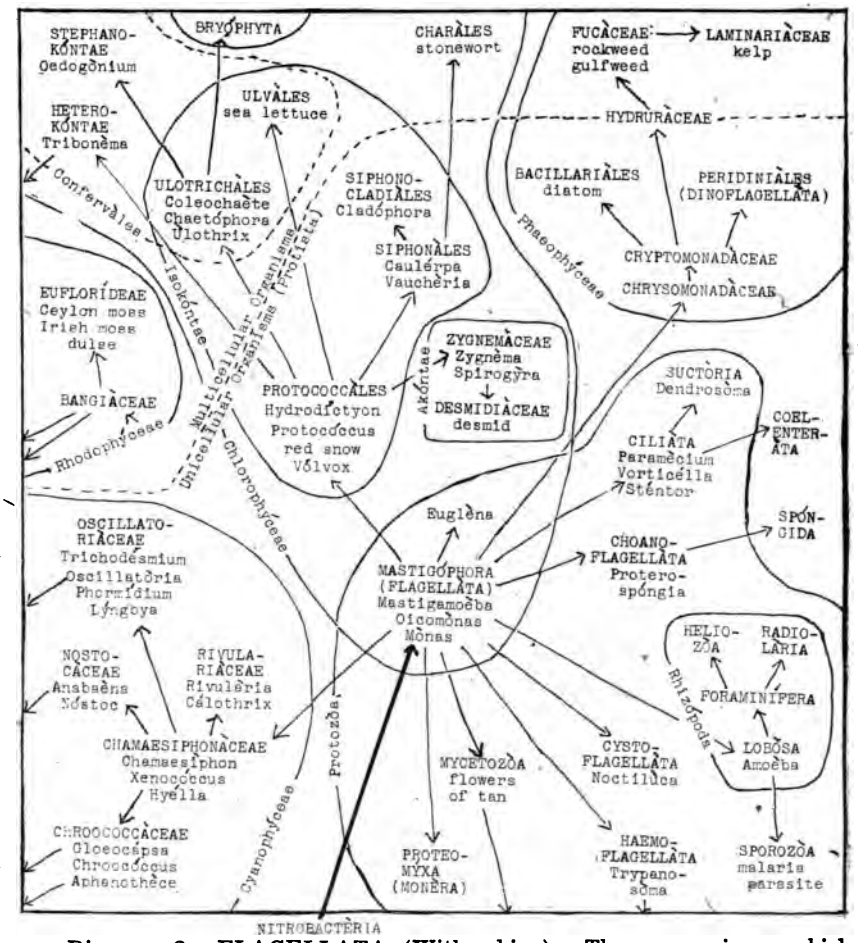

Diagram 2. FLAGELLATA (With whips). These organisms, which are provided with one or more whips or flagella, are claimed by botanists to be plants and by zoologists to be animals, and so the best that can be done is to let both have them.

CYANOPHYCEAE (Blue-green algae) are not always blue-green. The beautiful colors of the geyser region of Yellowstone Park are produced by various species of Cyanophyceae. Trichodesmium erythraeum (Red hair-bundle), a floating species, gives color and name to the Red Sea.

Star jelly or witches' butter, found on damp ground, consists of colonies of Nostoc.

Oscillatoria grows as slender filaments in hot springs and has a remarkable vibratory movement.

Rivularia and Calothrix grow in streams.

Anabaena causes a pig-pen odor in reservoirs.

CHLOROPHYCEAE (Green algae) fall into several groups according to the whips or "poles"—the Isokontae (Equal poles) the Heterokontae (Different poles), the Stephanokontae (Crown poles), and the Akontae (Without poles). One of the most curious forms is "red snow," the rounded resting cells of Chlamydomonas nivalis, which sometimes covers large patches of true snow in the arctic regions.

Protococcus viridis is the most abundant of all algae, giving a green color to the north or moist sides of the trunks of trees and to walls and fences.

Volvox, the globe animalcule, is a globular colony of individuals each provided with an eye and two "equal poles." The colony, consisting of a large number of individuals, rolls about in pond water as they all wag their poles, and yet the entire colony is only 1-50 of an inch in diameter. Despite the eyes and the active poles, Volvox is now regarded as a colony of plants.

Many of these lowly forms are in fact part animal and part plant. They were first plants (Nitrobacteria), then, as the animal method of nutrition began to preponderate they became animals, and where the vegetable method of nutrition overtook the animal they became plants again. Haeckel does not allow that these one-celled organisms are either plants or animals, but says they are Protista (Very first), the ancestors of plants and animals, not having yet become either, and there is much to be said in favor of this view.

RHODOPHYCEAE (Red algae) are seaweeds and include many beautiful forms.

PHAEOPHYCEAE (Brown algae). These also are seaweeds and include the gulfweed, of which there is a vast accumulation called the "Sargasso Sea" in the middle of the Atlantic, and "kelp," used in the manufacture of iodine and as a fertilizer.

PROTOZOA (First animals). Amoeba proteus, a favorite object of study with the microscope in schools, has lost the flagella of its ancestors. As the amoebae acquired the habit of growing shells they became Foraminifera (of which Globigerina and the money stone of which the pyramids are built are examples), Heliozoa (Sun animals), and Radiolaria, a constituent part of the Atlantic ooze.

Some of these forms degenerated into parasites such as that which produces malaria. Trypanosoma gambiense is the parasite that produces the sleeping sickness in Africa.

Mycetozoa (Fungus animals), regarded by many as plants and called Myxomycetes (Slime fungi), are probably degenerate Flagellates. One species, Fuligo septica, forms yellowish cakes on tan-heaps, and is called "flowers of tan."

Noctiluca is phosphorescent and sometimes lights the sea at night.

Euglena viridis forms colonies in water or wet places, each individual having one flagellum and a bright red eye.

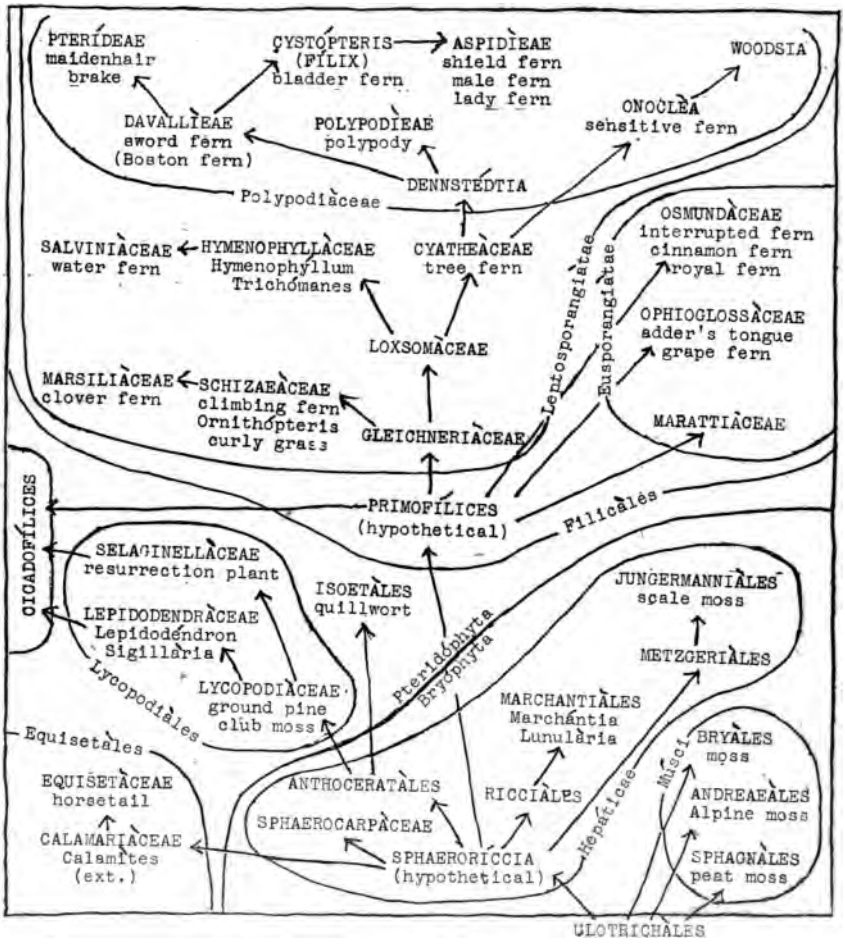

Diagram 3. PTERIDOPHYTA (Fern plants), etc. Mosses and the Hepaticae (Liverworts) sprang from the green algae, and the lycopods, horsetails, and ferns from the liverworts.

At the top of the ferns is the Polypody family, which embraces many of the most familiar species, as the sword (or Boston) fern whose long fronds are seen in many windows, and the beautiful little maidenhair.

Ferns reproduce themselves by means of spores, almost invisible to the eye, which grow in little covered bunches forming the dots that sometimes appear on the under side of the fronds. In the maidenhair and some others the dots appear at the turned-over edges of the frond.

Male ferns and lady ferns are so named from an erroneous opinion of the ancients. The powdered root of the male fern has been used as a remedy for tapeworms.

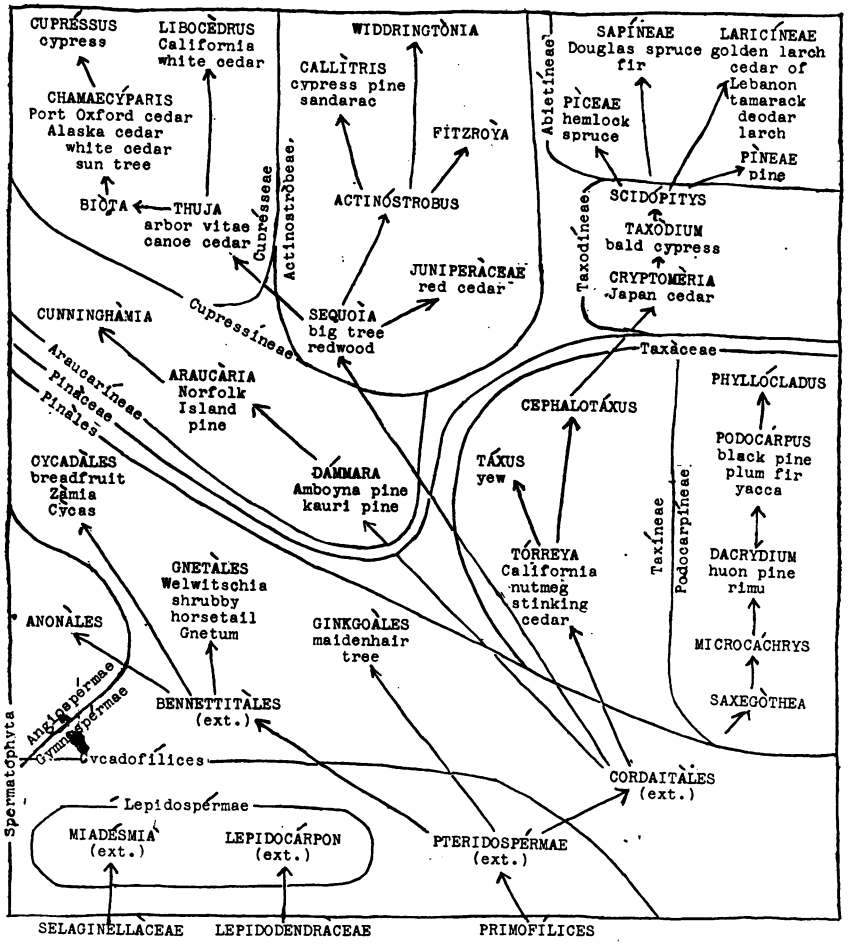

Diagram 4. GYMNOSPERMAE (Naked-seeded). Gymnosperms were the first plants to produce seeds. Before that plants produced only spores, which are somewhat of the nature of detached buds. Then they produced two kinds of spores—megaspores (big spores) and microspores (little spores). It is the union of a little spore with a big one that produces a seed. In the perfect flower the big spore is where the seed is afterward found, and the little spores are the pollen grains. Unless the big spore is fertilized by a pollen grain it will not develop into a seed.

Ferns now produce only spores, but one branch of the ancient ferns, the Pteridospermae (Seed-ferns), acquired the habit of producing seeds, and are therefore classed with the Gymnosperms. Two branches of the Lycopods also crossed the line and became seed-bearing plants.

Seeds are either naked (Gymnosperms) or clothed (Angiosperms), and the naked ones came first; clothes being a later development.

The big trees of California are remnants of an ancient stock—the ancestors of the cypresses and cedars—that lingers on in that state.

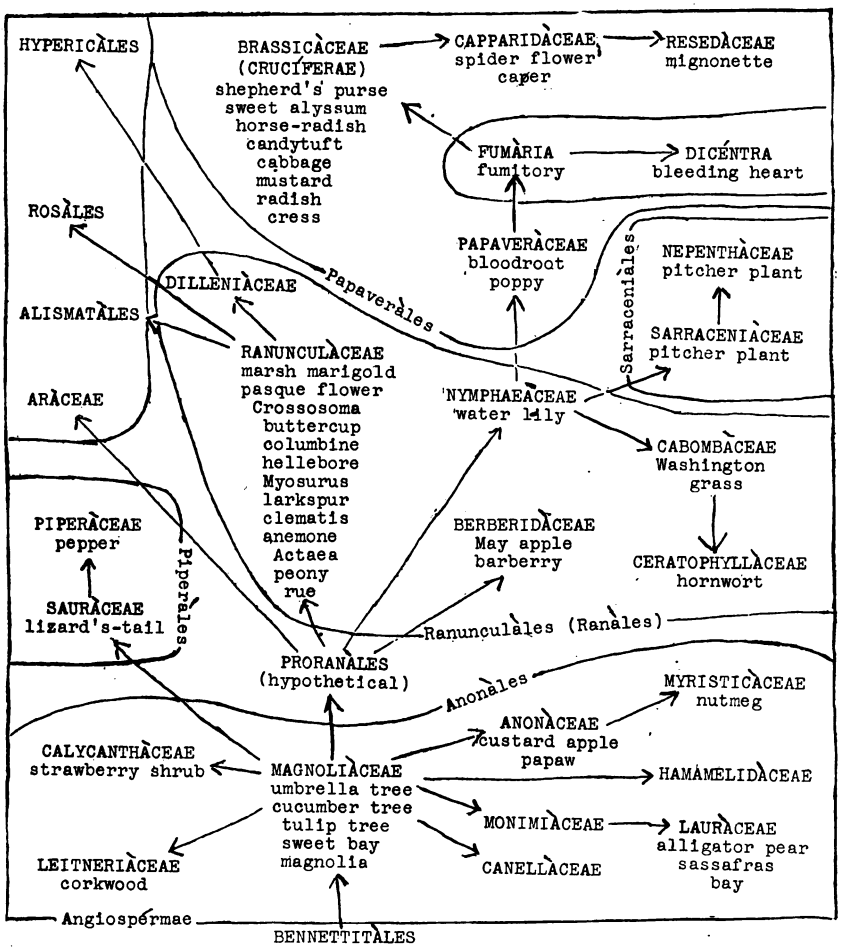

Diagram 5. ANGIOSPERMAE (Clothed seeds). When the naked seeds of the Gymnosperms clothed themselves with skins or otherwise they became Angiosperms. At the bottom of the Angiosperms stands the Magnolia family, containing a number of remarkable trees, one of which, the tulip tree, otherwise known as the yellow poplar or whitewood, with flowers resembling the tulip, grows to be six feet in diameter. All of the family have a cone-like fruit the form of which is [illegible]ted from the Gymnosperms (though this point is disputed).

The buttercup family is a large and important one, and some make it ancestral also to the water lilies and the Araceae.

The water lilies branched out in three directions, one branch leading to the Washington grass (a beautiful aquarium plant), another to the curious pitcher plants culminating in Nepenthes (Sorrow-remover), which Linnaeus said would remove the sorrow of any botanist who would contemplate its wonderful structure, and another to the poppy family.

The poppies lead to the fumitory, and the fumitory to the bleeding heart and Dutchman's breeches, and also in another direction to the Cabbage family, and at the end of that line comes the mignonette.

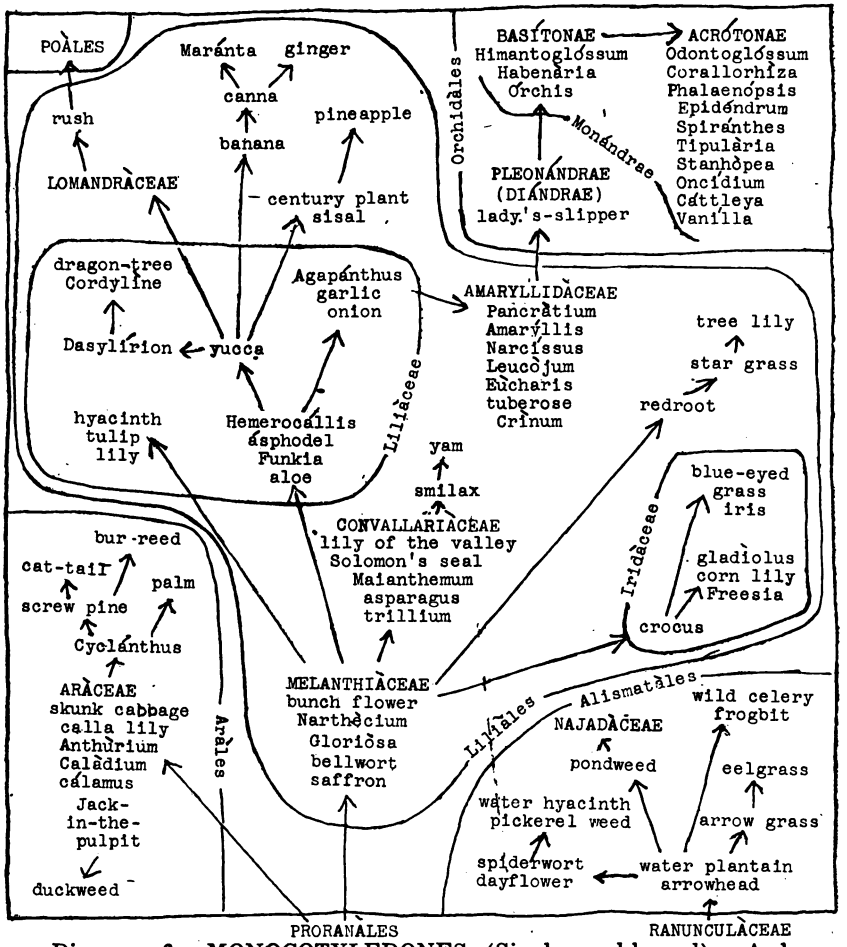

Diagram 6. MONOCOTYLEDONES (Single seed-leaved). A large group of plants, as the grasses, lilies, palms, and many water plants, in sprouting send up a single seed-leaf, while others, the Dicotyledones, send up two. Probably the monocots came from the dicots by suppression of one seed-leaf, or by the delay of one which comes up later, making the leaves alternate instead of opposite. Many of the dicots in fact become alternate-leaved as the plant grows.

The relationships of the Arales and the Alismatales are obscure, and there is much difference of opinion.

LILIALES (Lily order). To the Lily family belong not only the lily, but also the tulip and hyacinth, which are very near relatives, and the asphodel, onion, yucca, and dragon-tree, a célebrated specimen of which in the Canary Islands was believed to be 5,000 years old when blown down in 1868.

Asparagus, though so different in appearance, goes with the lily of the valley, as witnessed by the flowers. Asparagus is a desert plant which to save water has dispensed with its leaves. The greenhouse plant called "smilax" is an asparagus that after getting rid of its leaves needed them again, but found it easier to develop false leaves (cladophylls) than to restore the old ones. The true smilax, however, is the greenbrier, which stands for the ancestor of the yam.

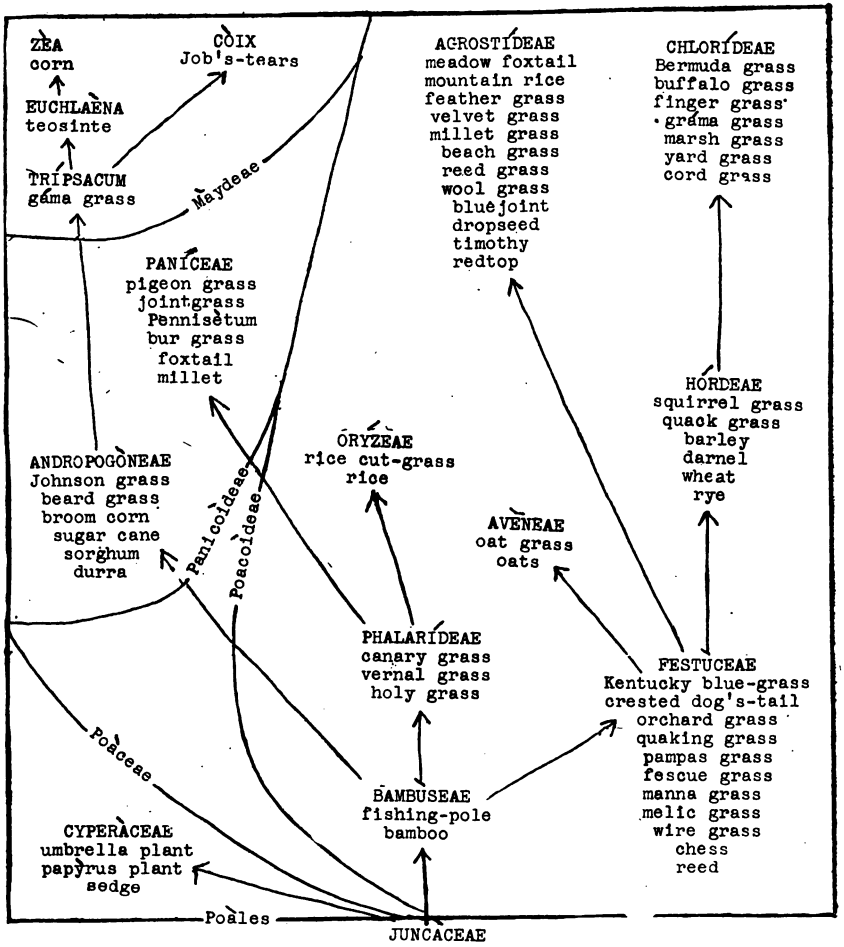

Diagram 7. POALES (Grass order). Botanists have had great difficulty with the grass family (Poaceae). For a long time the corn tribe was regarded as the lowest and placed at the bottom, with the bamboos at the top, but now the scheme has been reversed, with the bamboos at the bottom and the corn tribe at the top. Indian corn and Job's-tears took different directions, and it is difficult to decide which actually stands at the top of all the grasses.

Grains of corn grow on a cob which is formed by the union of a number of spikes, each spike carrying two rows of corn; and so an ear of corn always has an even number of rows—twice the number of spikes that make up the cob. In Job's-tears the grains do not grow on cobs, nor even in spikes, but singly, and not being crowded together are not flattened, but bead-shaped, and are often strung and worn as beads.

Each grain of corn has a long thread of silk, these silks being the stigmas of the corn flower which must be fertilized by the pollen that falls down from the tassel. The silks and tassel which formerly grew together in the same flower are now separated, with the tassel above the silks, that the pollen may the more readily fall upon the silks.

Sometimes the cornstalk forgets itself and attempts to produce ears of corn in the old way at the top.

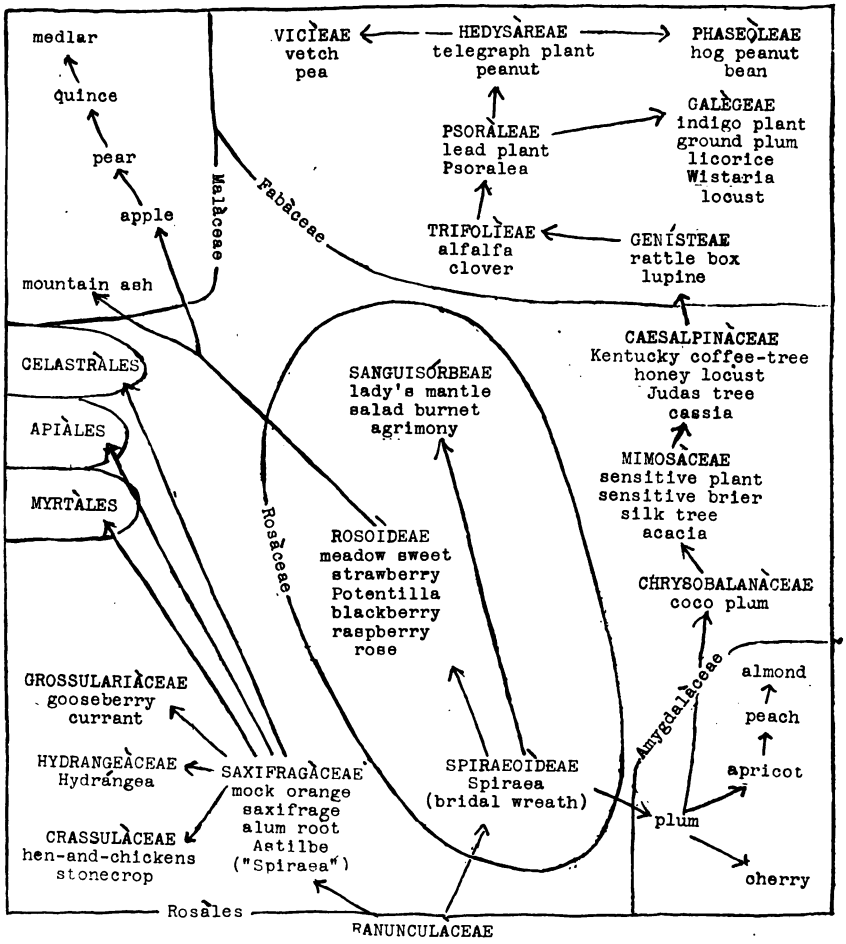

Diagram 8. ROSALES (Rose order). The 11 principal families of this order produce many of the most valuable fruits, field crops, and flowers.

Roses were apparently developed from the Buttercup family (some say from the Tea family), and apples from the roses; the seed-ball of the rose, or something very like it, being converted into an apple.

The plum, on the other hand, is merely a seed that outgrew its fellows, gathered flesh, and became a fruit with a pit. This explains why apples have a blossom end while plums do not. When the plum wrinkled its seed and grew fuzzy it was an apricot or peach, and when the peach hardened its flesh it was an almond.

To make the raspberry and blackberry all the seeds gathered flesh.

To make the strawberry the torus (bottom of the flower) became swollen and pulpy, with the seeds embedded in the surface.

The Judas tree or redbud is the one on which Judas is said to have hanged himself.

The Astilbe is often miscalled "Spiraea"; the true Spiraea being the bridal wreath.

The telegraph plant has the curious habit of wagging its side leaflets on warm days.

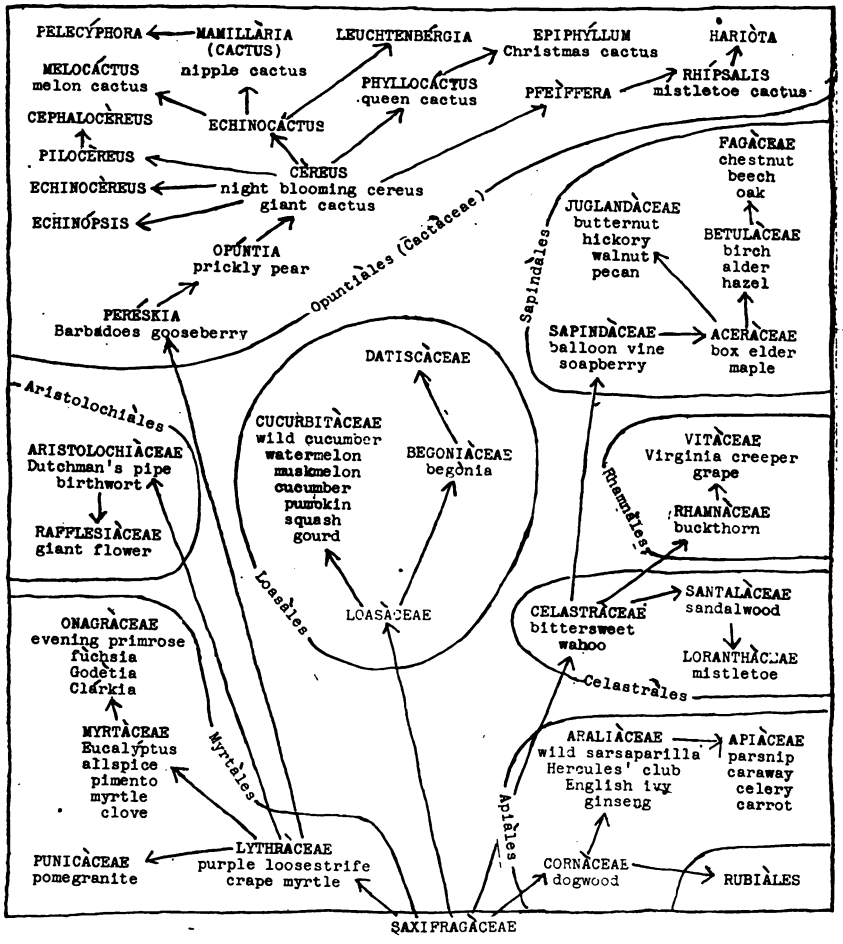

Diagram 9. CELASTRALES, etc. The orders shown here probably came from the saxifrages. Mistletoe comes from the Sandalwood family, grapes from buckthorns, oaks and beeches from the Birch family, and the Maple family may be ancestral to the Birch and Walnut families, though the matter is in doubt.

A species of evening primrose, transplanted from a poor to a rich soil, suddenly developed from its seed several new species, furnishing De Vries with his theory of evolution by mutation.

Rafflesia arnoldi, of the East Indies, produces the largest flower that grows, being three feet in diameter and weighing fifteen pounds. It is a parasite growing on the stems and roots of Cissus vines, from which it derives its nutriment. It has no stem, no branches, no leaves—nothing but rootlets to suck the juices from the vine—and the flower, which begins as a little knob, grows to resemble an immense cabbage before it opens into a flower.

Cactuses come from the Barbadoes gooseberry, which, however, is not a true gooseberry, and its origin is doubtful.

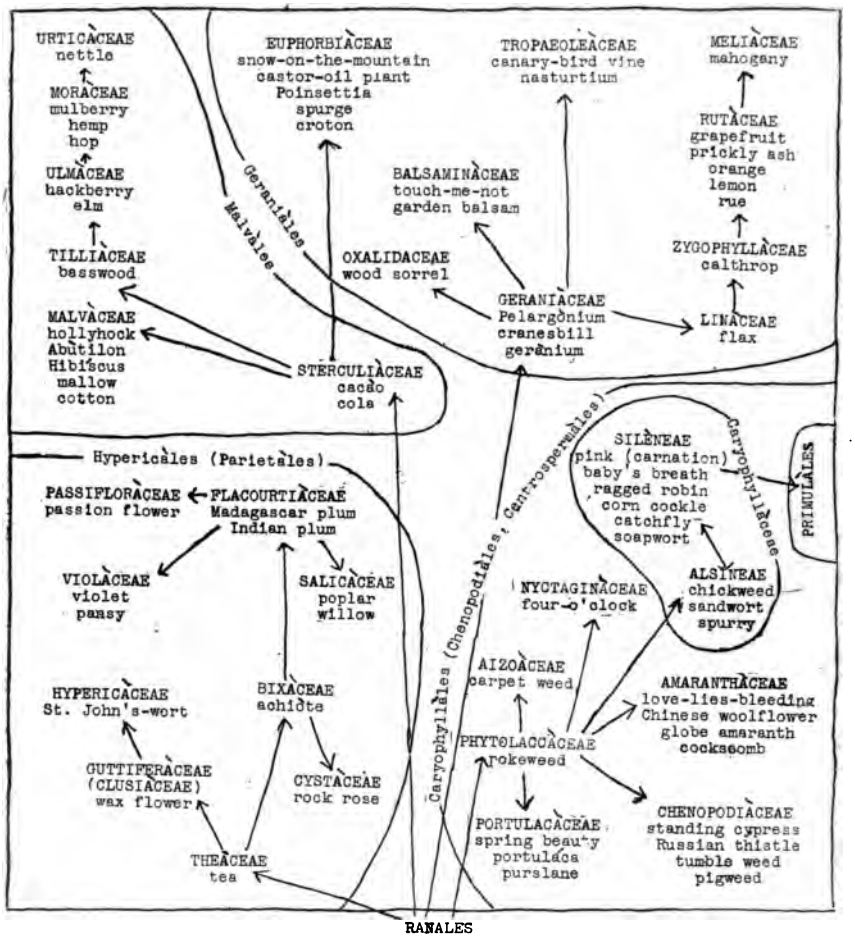

Diagram 10. HYPERICALES, etc. From the Tea family have been developed, directly or indirectly, the wax-flowers, St. John's-wort, the rock rose, and the Indian plum. The passion flower, in which the Spanish discoverers thought they could see all the emblems of the crucifixion, probably came from the Flacourts, as also the pansies and violets. Garden pansies have been developed from a wild violet (Viola tricolor).

Willows are degenerate poplars, and poplars are degenerate Flacourts, or, perhaps, degenerate tamarisks.

The hop and hemp of the Mulberry family lead to the nettles.

The Spurge family, which produces the beautiful Poinsettia, is difficult to place.

The amaranths take their name from the mythological flower that never fades. The colored bracts of the globe amaranth, cockscomb, and other species resemble flowers and hold their own for a long time, and are used for winter bouquets.

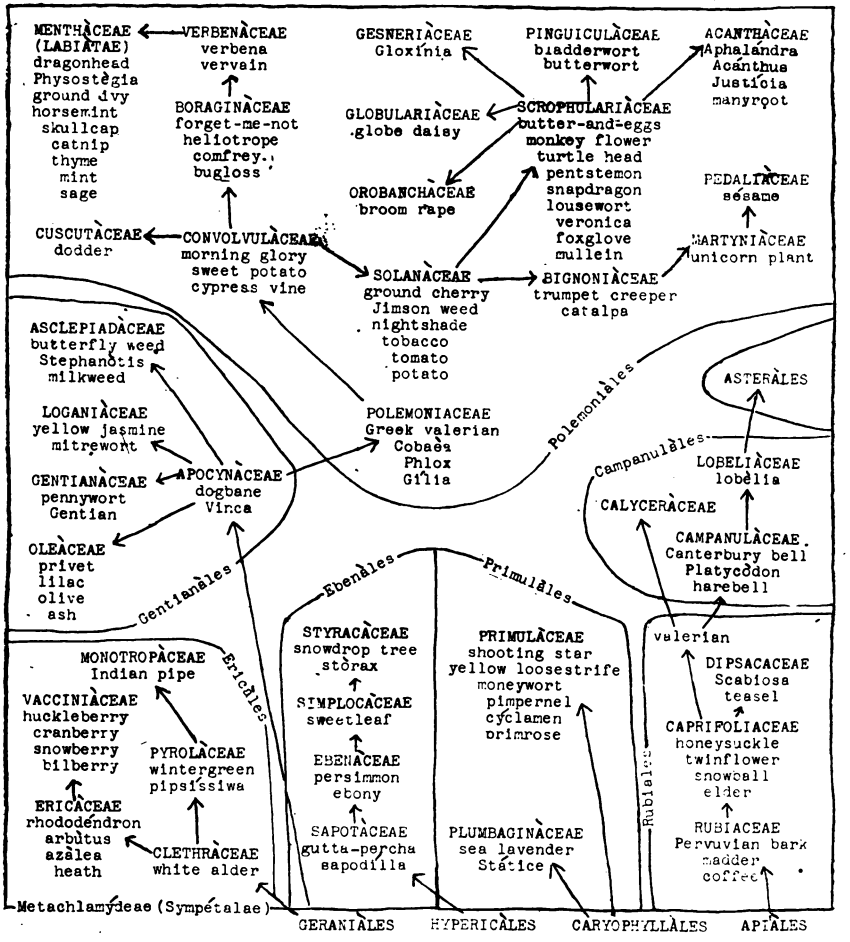

Diagram 11. POLEMONIALES, etc. The orders shown here belong to the Sympetalae (Petals united), the petals of their ancestors being united to form a tubular or bell-shaped flower. The seams where the petals were united may still be seen in many flowers, as the morning glory.

Flowers with separate petals belong to the Archichlamydeae (Primitively clothed), and those with united petals to the Sympetalae, which is another name for Metachlamydeae (After-clothed, i. e., dressed in later style), the latter having been developed from the former. The flowers that dress in this new fashion are included in this diagram and the next.

The sweet potato comes from the morning glory, and so does the dodder that twists itself around other plants.

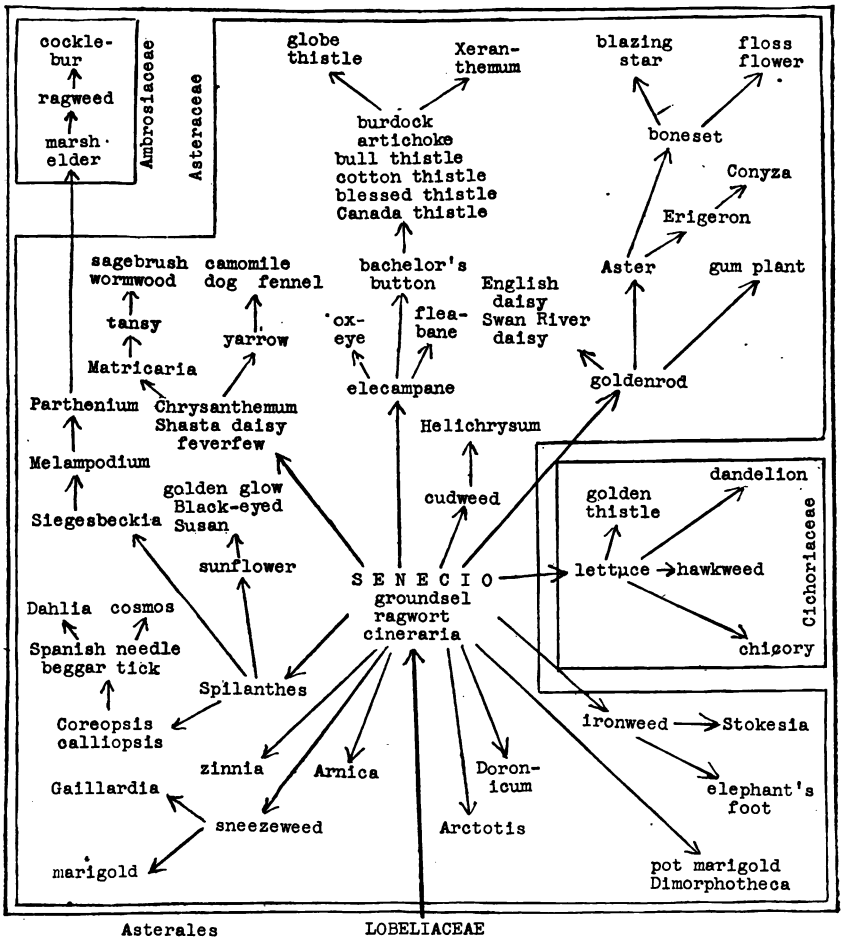

Diagram 12. ASTERALES (Aster order). In the Cretaceous period, some 6,000,000 years ago, at the time when the Andes Mountains were elevated above the sea, one section of the Lobelia family spread over the newly-made land and under the new conditions there prevailing was transformed into the genus Senecio, the beginning of the Aster family, now the largest and most highly developed family of plants.

While still in the Andes some Senecios became cudweeds, and some became Spilanthes (spot flowers), and in Brazil some Senecios became ironweeds. Some spot flowers, reaching Mexico, became sunflowers, and others, coreopses. In the United States some Senecios became goldenrods, and some goldenrods became asters. Some asters, working back to Mexico, became Erigerons, while others, going on to Brazil, became bonesets. Some Senecios, reaching Alaska, crossed over to Asia; elecampane being developed in Asia, bachelor's buttons, thistles, lettuce, chrysanthemums, and yarrow in the Mediterranean region, and Helichrysums and pot marigolds in Africa.

Dandelions come from lettuce. A lettuce plant in flower or seed looks like a family of little dandelions.

Bachelor's buttons are the beginning of the thistles.

The dahlia and cosmos come from the coreopsis, the Gaillardia and Marigold from sneezeweed, and the English daisy from the goldenrod.

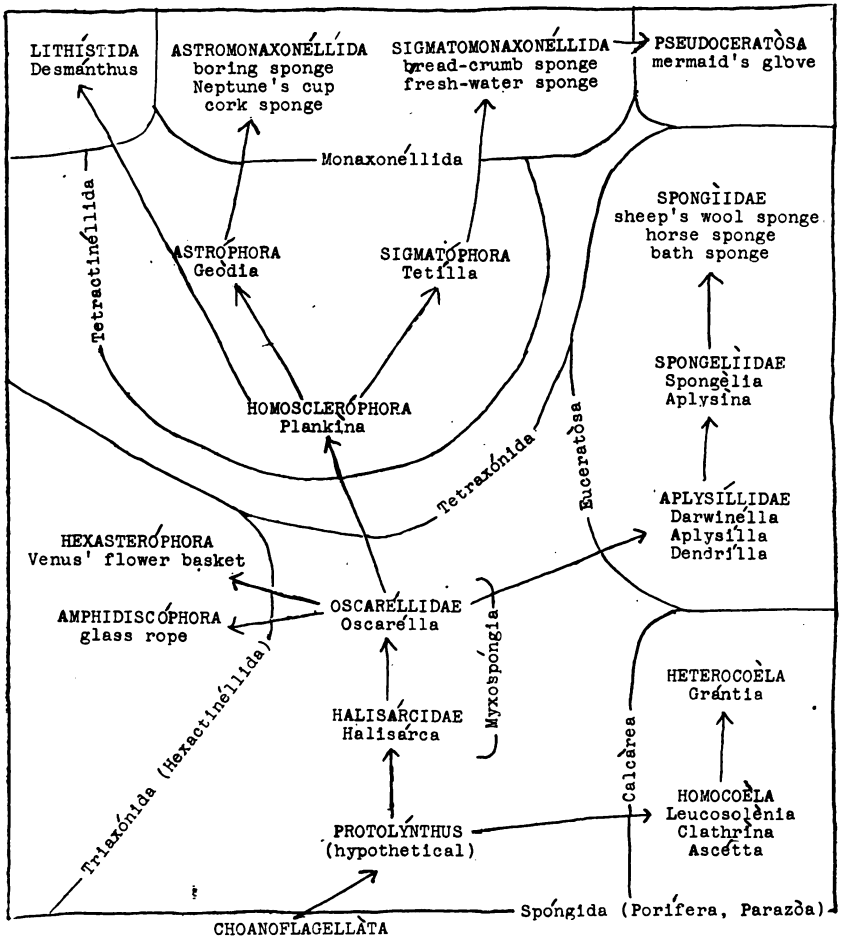

Diagram 13. SPONGIDA (Sponges). The most primitive of existing sponges being of the olynthian (fig-like) form, the hypothetical first sponge has been named Protolynthus (First fig). Most sponges have skeletons composed of spicules (little spikes), and those long Greek names describe for the most part the shapes of the spicules. The Calcarea have chalk skeletons, the Euceratosa, horny, fibrous skeletons, and all the rest above the Myxospongia (Slime sponges) which continue to get along as their ancestors did, without any, of silica or stone, which sometimes resembles spun glass.

Venus' flower basket (Euplectella aspergillum), the most beautiful of the glass sponges, comes from the Philippines.

The boring sponge (Cliona celata) bores small holes in rocks and in the shells of oysters and clams. The limestone rocks on the Dalmatian coast are riddled for hundreds of miles with the holes of the boring sponge.

Neptune's cup (Poterion amphitritae), the largest sponge, four feet high and three feet across, grows in the Pacific. The name means Amphitrite's cup; but as Amphitrite was Neptune's wife, the cup may have been community property.

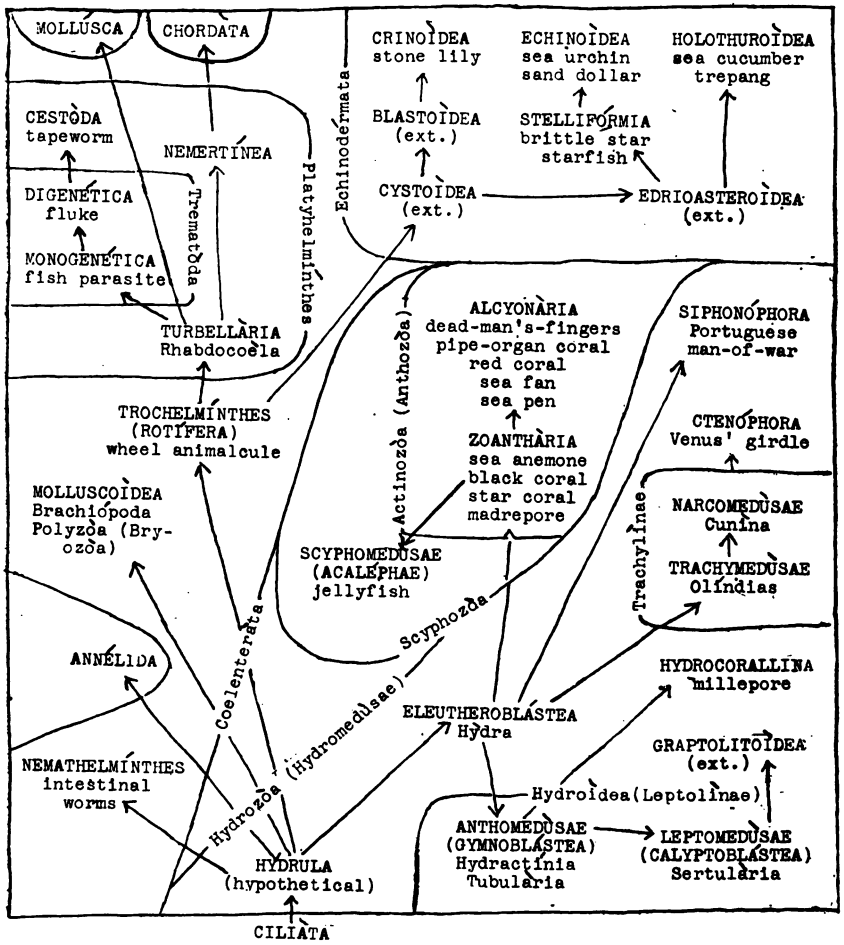

Diagram 14. COELENTERATA (Gut-hollowed) are derived from a hypothetical "hydrula" (little hydra) which is placed next to the Ciliata to be the ancestor of higher forms of life. Though no "hydrula" has been discovered, its former existence is inferred from the embryology of coelenterates, which begin with a hydrula stage.

Among the most advanced coelenterates are the Venus' girdle, phosphorescent at night, the Portuguese man-of-war, and sea-anemones, the latter having been fed until they learned to know when food was being offered them, and to reach out for it.

PLATYHELMINTHES (Flat worms) are not all flat, the tapeworm from which they are named being an extreme form. The Turbellaria and Nemertinea are important as probably in the line of development of higher animals.

ECHINODERMATA (With hedgehog skins). This name alludes to the spines of the starfishes, sea-urchins, and sea-cucumbers. Brittle stars, when caught, cast off their arms and break them into small pieces.

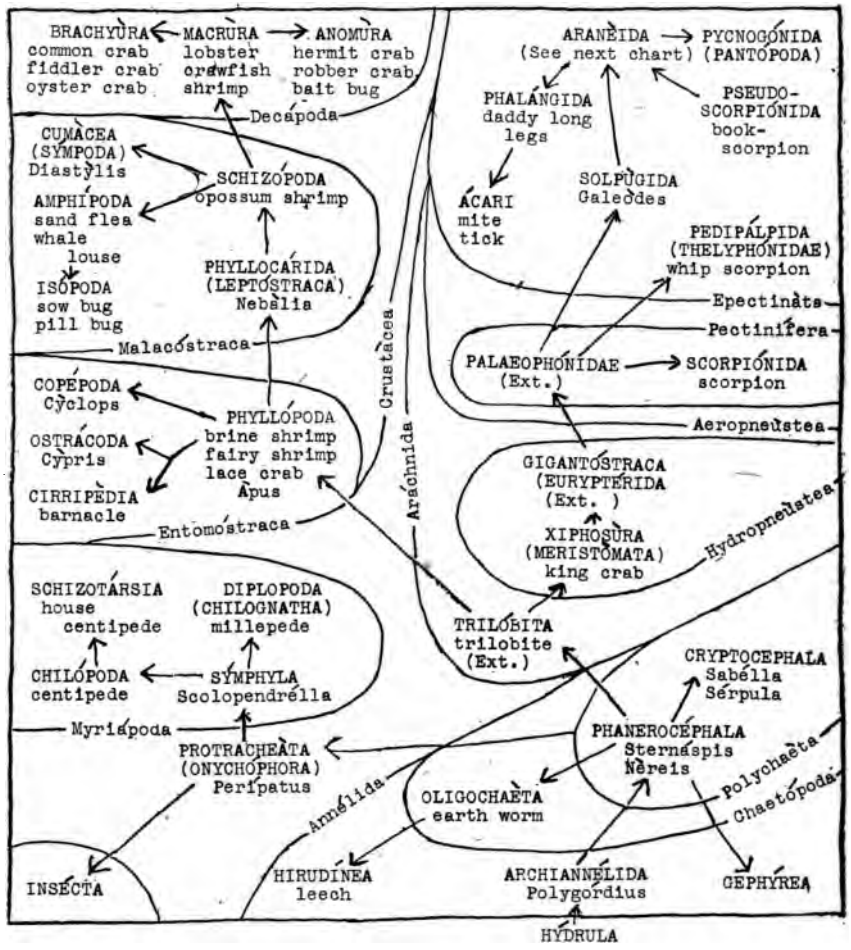

Diagram 15. ANNELIDA (Worms). The common earthworm is a degenerate, having lost its legs.

ARACHNIDA. This word means spiders, but the term covers also the ancestors of the spiders—the Solpugida, the scorpions, the king crabs, and the trilobites. The latter, so abundant in the Cambrian period, are ancestral also to the shrimps, lobsters, and crabs, and possibly to the insects.

CRUSTACEA (Incrusted). The phyllopods (leaf-footed) lead the way to shrimps, lobsters, and crabs, the short-tailed crabs coming from the long-tailed lobsters.

Barnacles are degenerate phyllopods. Darwin's book on the subject, which the reviewers said would make him famous, has almost been forgotten in the glory of his later works.

Daddy longlegs are degenerate spiders of the lowest group, and the mites and ticks are degenerate daddy longlegs.

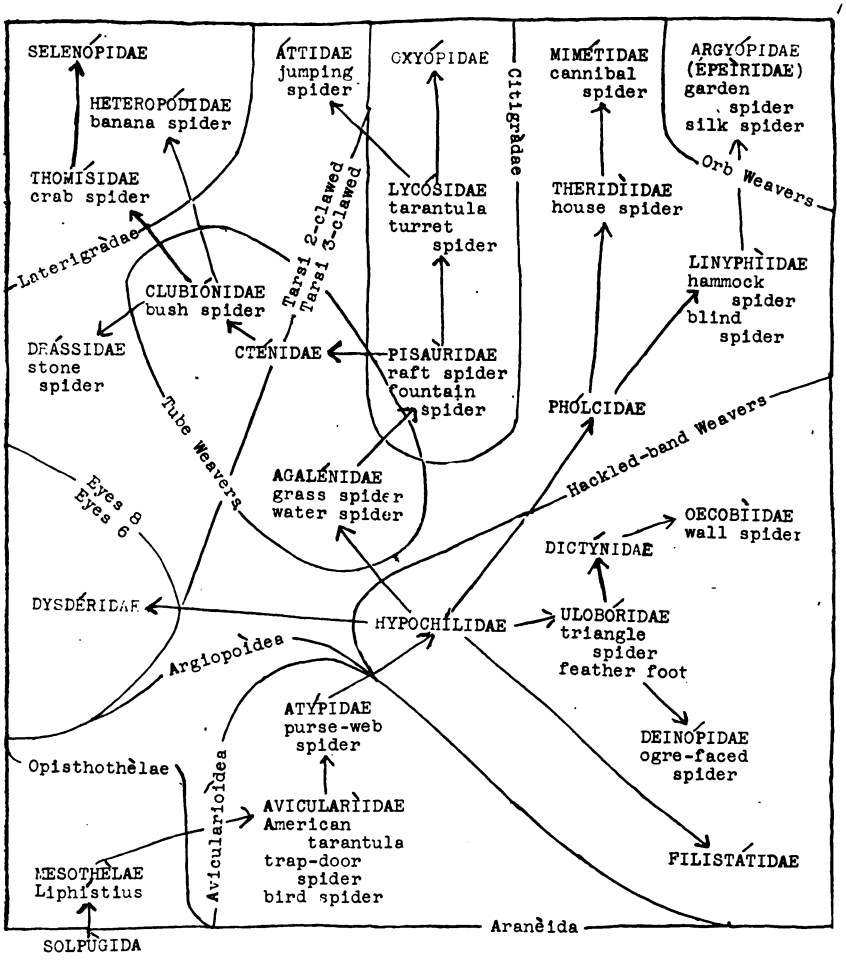

Diagram 16. ARANEIDA (Spider order). The lowest spider (Liphistius) retains the segmented abdomen of its ancestors which all other spiders have lost. The bird spider, which sometimes catches small birds, and the American tarantula come next.

Among the many wonderful spiders are the water spider of Europe, which makes its nest in ponds and ditches, carrying down bubbles of air with its legs—a splendid acquisition for an aquarium. It has been developed from the grass spider.

Ballooning spiders are generally young lycosids, though the thomisids are fond of the same sport. Desiring to migrate, they wait for a warm day, then throw out a line to the ascending currents of air, and when the pull is strong enough let go and sail away, sometimes to great distances, ballooning spiders having been observed at sea hundreds of miles from land.

The spider found in bunches of bananas is not a tarantula, though its bite is poisonous.

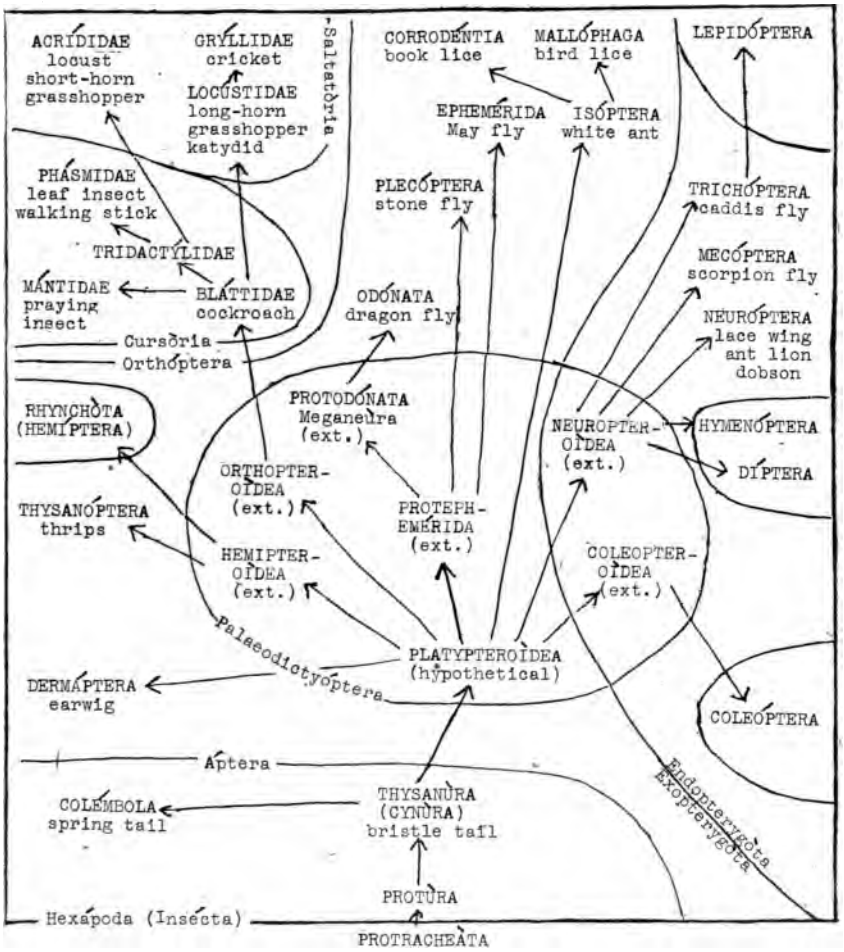

Diagram 17. INSECTA. The origin of insects is disputed, the general view having been that they are derived from the Protracheata, but many now believe them to be descended from the trilobites that were so abundant in early times.

All the fossil insects of the Palaeozoic have been grouped together as the Palaeodictyoptera (Ancient net-winged), which are taken to be the ancestors of modern insects. Meganeura, the largest known insect, had a wing-expanse of over two feet.

It is also disputed whether the Aptera (Without wings) are primitive and never had wings, or degenerate and have lost them.

Wings begin either as an external fold (Exopterygota—Outside-winged) or as an internal fold (Endopterygota—Inside winged), the inside method being the later.

It is believed that the chrysalis stage was imposed on certain insects by climatic conditions which at some former period compelled them to encase themselves in a shell for protection.

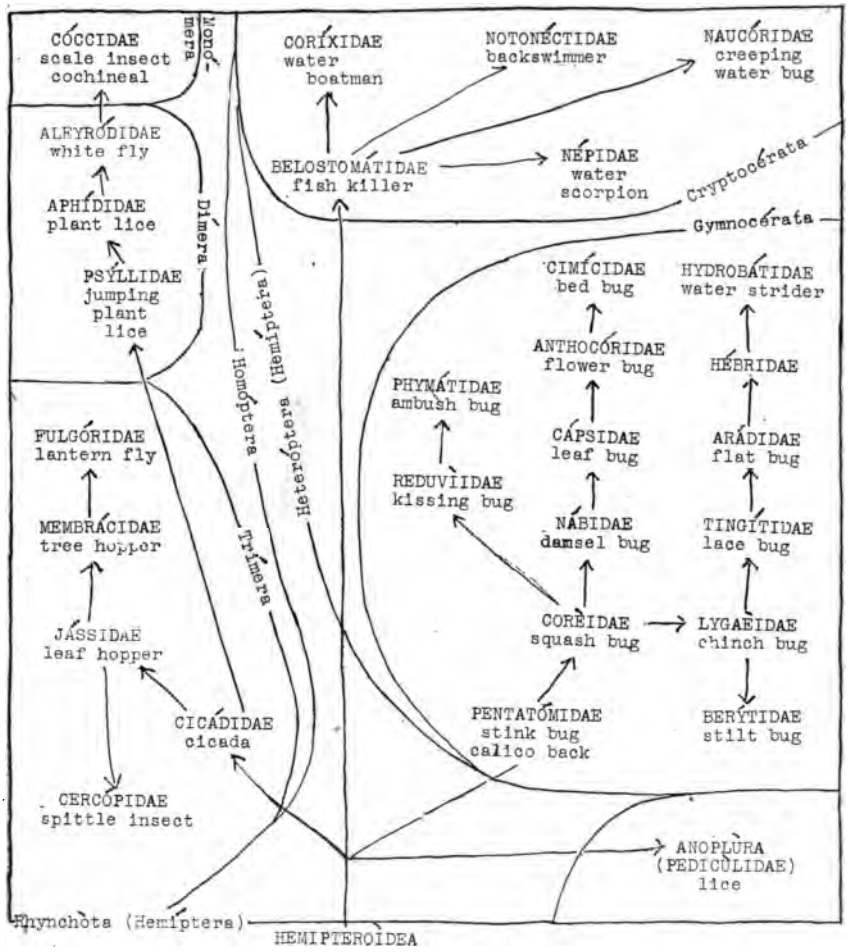

Diagram 18. RHYNCHOTA (Snouted). This is the bug order which sucks the juices of animals and plants, and is usually called Hemiptera (Half-winged), in allusion to the change of texture in the wing of one group, the portion next to the body being thick and the outer portion thin.

Bugs fall into three groups, one beginning with the Stink-bug family, another with the Fish-killer family, and the third with the Cicada family. The first two form a larger group and are the ones that have the thick-and-thin wings.

The Cicada family is ancestral to many curious insects. The spittle insect lays its eggs in a white foamy substance which it deposits on plants. Tree hoppers are the most grotesque of all insects, and are well calculated to provoke laughter when examined with a magnifying glass. Lantern flies have a large hollow proboscis which has been incorrectly said to emit light. Scale insects, so injurious to the orange-tree, stand at the end of another line.

The fish-killer is one of the largest of bugs, and is also called the electric light bug, from being attracted to electric lights as it flies from one body of water to another.

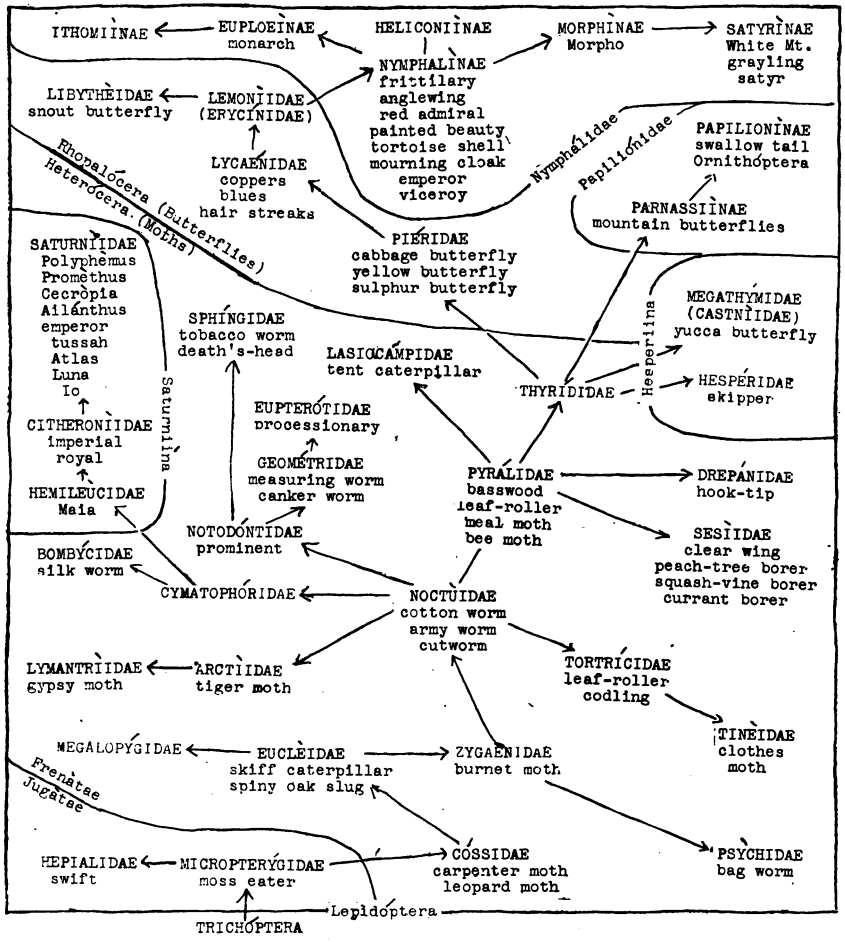

Diagram 19. LEPIDOPTERA (Scaly-winged). The dust that comes off the wings of butterflies and moths, when examined under the microscope, proves to be in the form of scales covering the wings like shingles on a roof.

Butterflies come from moths. Butterflies constitute the group Rhopalocera (Club-horned), the feelers generally being club-shaped with an enlargement at the end, while the moths, or Heterocera (Differently horned) have feelers of various kinds, many of them feathered.

Linnaeus, who first systematically gave scientific names to things, was so impressed with the splendid colors of butterflies that he thought them worthy of the names of the ancient Greek and Trojan heroes, and so he called one species Papilio Agamemnon, another Papilio Paris, another Papilio Hector, and so on. Others have followed his example, and now there is scarcely a god, goddess, hero, or heroine of antiquity who has not had his or her name transferred to a butterfly.

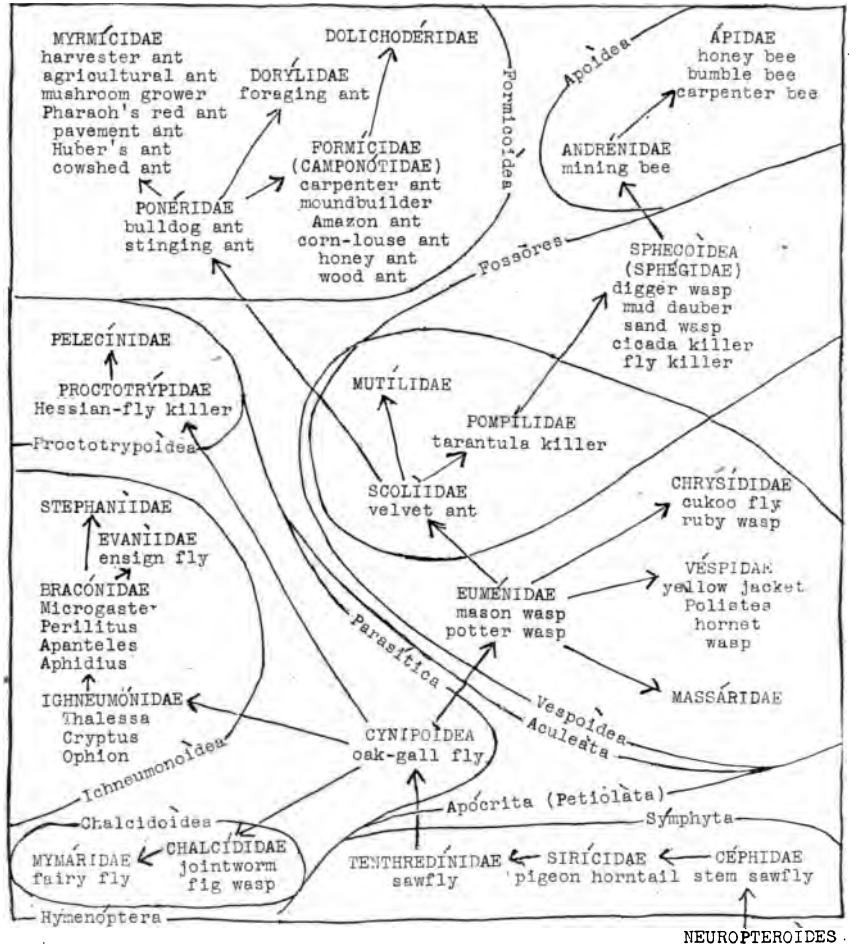

Diagram 20. HYMENOPTERA (Skinny-winged). One scarcely thinks of ants as having wings, but the ants commonly seen are the workers who have got rid of their wings as a nuisance.

The sawfly group, at the bottom of the Hymenoptera, belong to the old school and do not believe in narrow waists. But their descendants do, and so the wasps, bees, ants, and their parasitic relatives are almost cut in two in the middle.

Ants are said to come next to man in intelligence. They enslave other ants, build sheds over aphids, which they milk as cows, and make hotbeds in which they grow a certain fungus or ant mushroom for food. Some have been slaveholders so long, and are so accustomed to be waited on, that, though great fighters, they can no longer feed themselves and would starve to death in the midst of food were there no slaves to feed them.

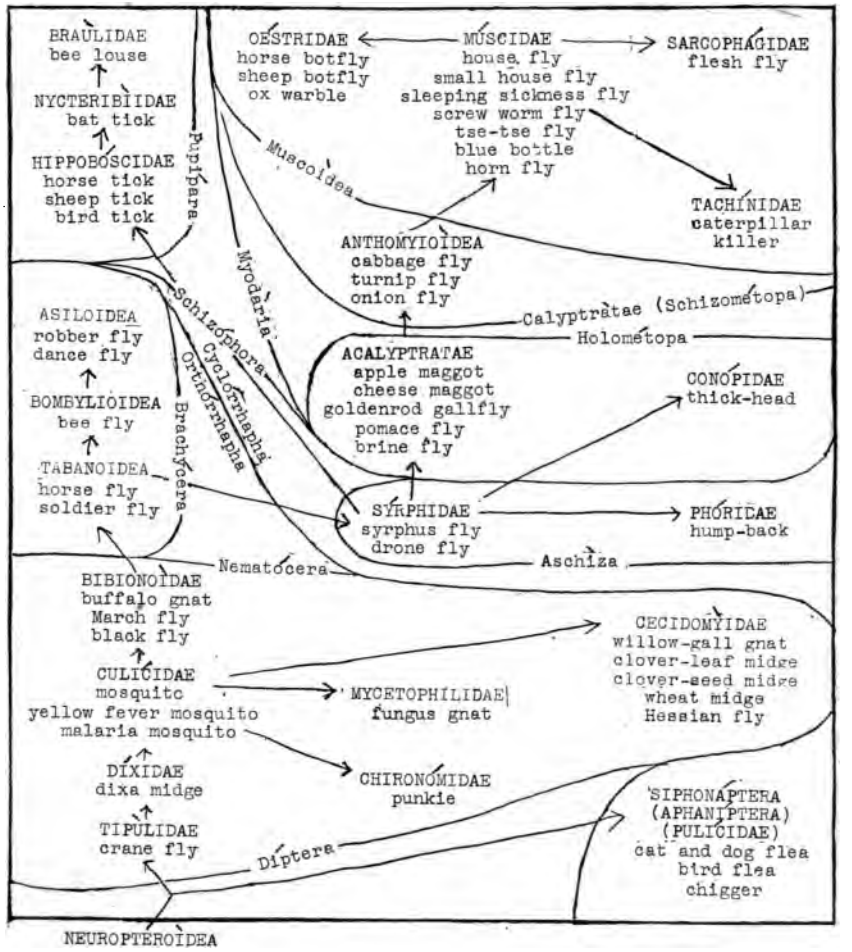

Diagram 21. DIPTERA (Two-winged). Flies having two wings whereas other insects have four, the inference is that flies have lost two of theirs. Sure enough, in the place where the hind pair of wings ought to be are found a pair of club-like balancers which can only be regarded as the degenerate representatives of ancestral wings.

Houseflies are higher in the scale than horseflies, which in turn are higher than March flies and buffalo gnats. This last group came from the mosquitoes, mosquitoes from dixa midges, and dixa midges from crane flies, in which the balancers are very large and prominent, as one would expect in forms nearer to the four-winged ancestors.

Botflies and horseticks are special developments.

Fleas are more closely related to the flies than to any other order of insects, and are to be regarded as an offshoot from some point on the line between crane flies and the extinct Neuropteroidea.

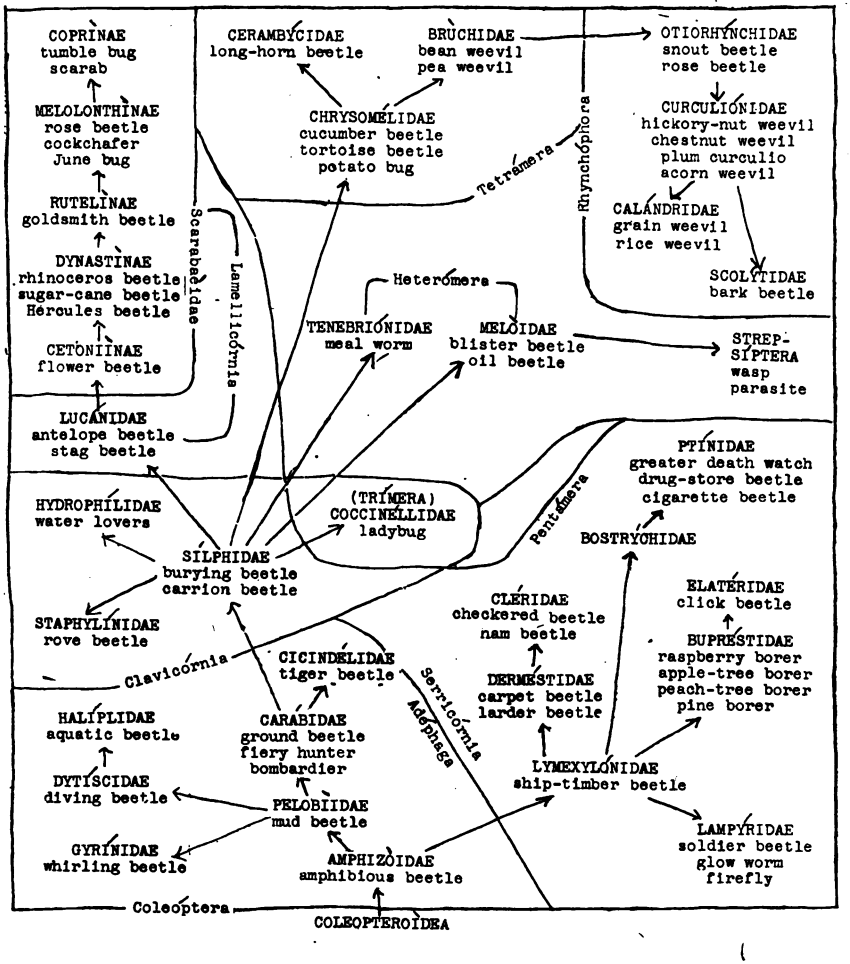

Diagram 22. COLEOPTERA (Sheath-winged). Beetles have a pair of hard wings to protect the soft ones which alone are used for flying.

One method of classifying beetles is according to the number of joints in the foot, some being 5-jointed (Pentamera), some 4-jointed (Tetramera), and some 3-jointed (Trimera). The 5-jointed are the most primitive, the others having lost one or more joints by consolidation.

Another method is according to the forms of the antennae (feelers). Some are club-shaped (Clavicornia), some have saw-teeth along the inner side (Serricornia), and some have at the end of the feeler a number of plates which fold together like the leaves of a book (Lamellicornia). It is disputed whether the Clavicornia or the Serricornia came first. Very likely they represent two lines of development from ancestors with straight feelers. But the Lamellicornia no doubt came from the Clavicornia.

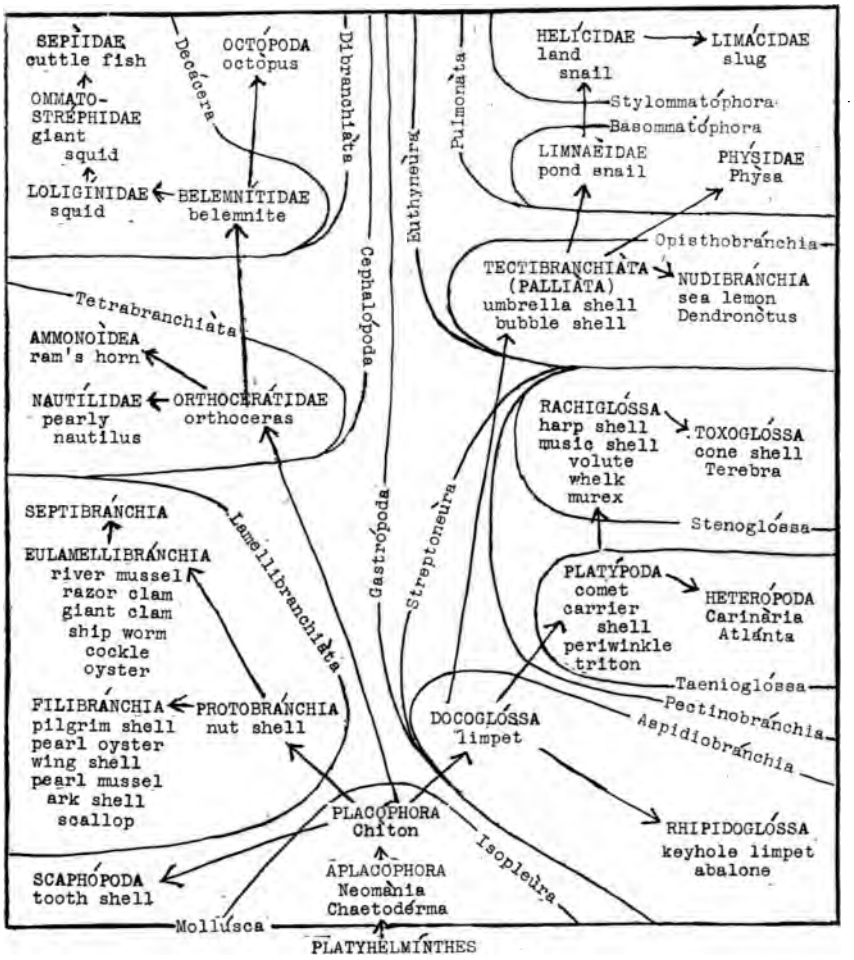

Diagram 23. MOLLUSCA. The first mollusks, Aplacophora (Carrying no cakes), were without shells. They were followed by the Placophora (Carrying cakes), having a shell of eight segments on their backs. From these came, first that great group of twisted shells, the Gastropoda (Stomach-footed), such as conch shells and snails, which seem to use their stomachs for feet.

Slugs are snails that have lost a part or all of their shells. Land snails carry their eyes at the end of long tentacles and are called Stylommatophora (Carrying eyes on a style), while pond snails have them at the base of the tentacles and are called Basommatophora (Carrying eyes at the base).

Another group is the Cephalopoda (Head-footed), having a straight or coiled (not spiral) shell, and with arms (or feet) encircling the head, of which the squid, cuttlefish, and octopus are examples. The cuttlefish has turned itself inside out, bringing its shell inside the body, where it has degenerated until all that is left of it is the bone that canaries sharpen their teeth on.

From the Placophora came still another group, the bivalves, with two shells connected by a hinge, as the oyster and clam.

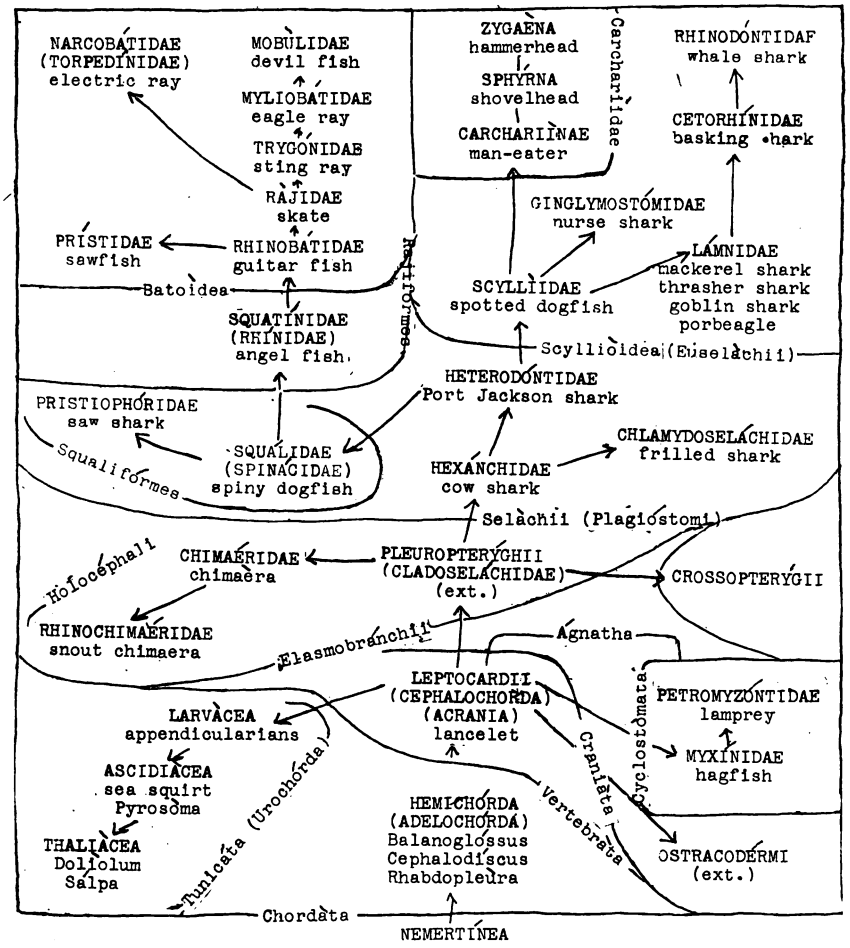

Diagram 24. ELASMOBRANCHII (Plate-gilled). This group comes from the lancelets, and the chimeras are one of the early offshoots. The Selachii (Sharks) begin with the cow shark and proceed to the Port Jackson shark, which became the ancestor of two lines of development, one leading to the angel fish, sawfish, skate, sting ray, eagle ray, devil fish, and electric ray, and the other to the true sharks. From the spotted dogfish family came, in one line, the man-eater, the shovelhead, and the hammerhead, and in another the porbeagle, the basking shark, and the whale shark. The latter is the largest of all sharks, exceeding 40 feet in length. A whale shark (Rhinodon typicus), with a throat large enough to swallow a man, was captured on the coast of Florida in 1912 and exhibited in various cities as the whale that swallowed Jonah!

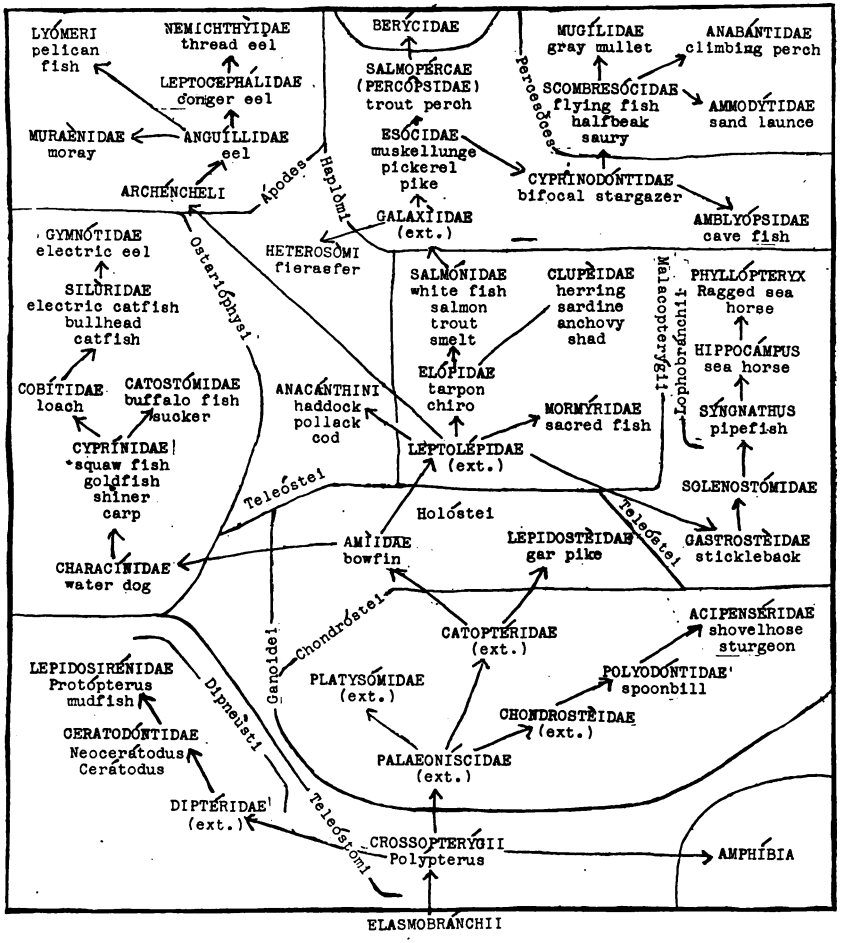

Diagram 25. FISHES (1). Fishes begin with the Crossopterygii (Fringe-finned), of which only a few survive. From the extinct ones come the Dipneusti (Double breathers), a curious group which, having developed lungs to use out of water, have been regarded as the ancestors of the Amphibia, though they are more probably another line that stopped short of becoming real amphibians. Nature seldom succeeds in her first efforts.

Ganoids and other early fishes have cartilaginous skeletons, the cartilage hardening into bone in the higher groups.

The sacred fish was worshiped by the ancient Egyptians as having eaten one of the pieces of their dismembered god Osiris.

The bifocal stargazer, called "four-eyes," has the lower half of the eye adjusted to see in the water and the upper half to see in the air.

The climbing perch of India climbs trees to the height of several feet when it rains.

Fishes in Mammoth Cave have nearly lost their eyes from disuse.

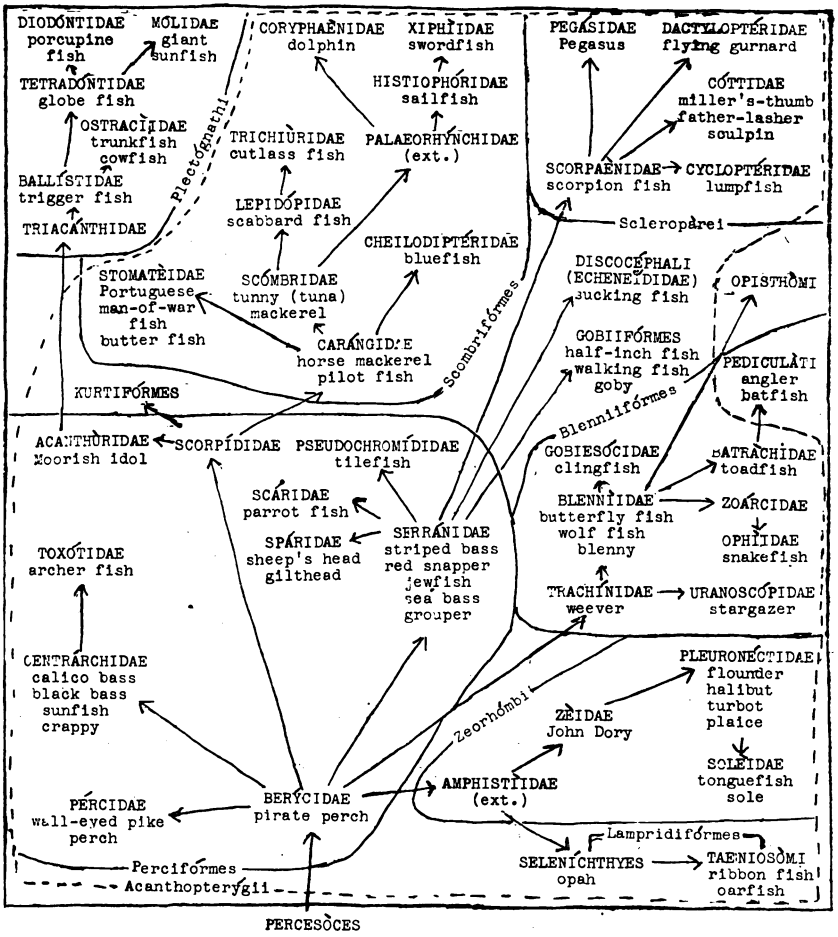

Diagram 26. FISHES (2). The acanthopterygian (spiny-finned) fishes begin with the pirate perch family, from which many remarkable forms have been developed. The halibut family lie flat on one side near the bottom of the sea, and the under eye, to get out of danger of striking something, moves around to the upper side, so that both eyes are on the dark or upper side of the fish. In the sole the eye takes a short cut and moves **through** the head to the upper side.

Pegasus, the flying horse, which has a pair of fins resembling wings, though not for flying, formerly classed with the sea horses, has been shown to be a greatly modified member of the Scleroparei (Hard-cheeks).

Swordfishes and sailfishes come from the mackerels.

Sucking fishes attach themselves by means of a disk to larger fishes and to vessels to rest themselves or steal a ride—a phenomenon which led to the ancient belief that they could stop ships in their course; whence the Latin name **Remora** (Obstruction) and the Greek **Echeneis** (Holding back ships). Pliny in his Natural History says that Antony and Cleopatra were defeated by Octavius at the battle of Actium (31 B. C.) because the sucking fishes held back their ships!

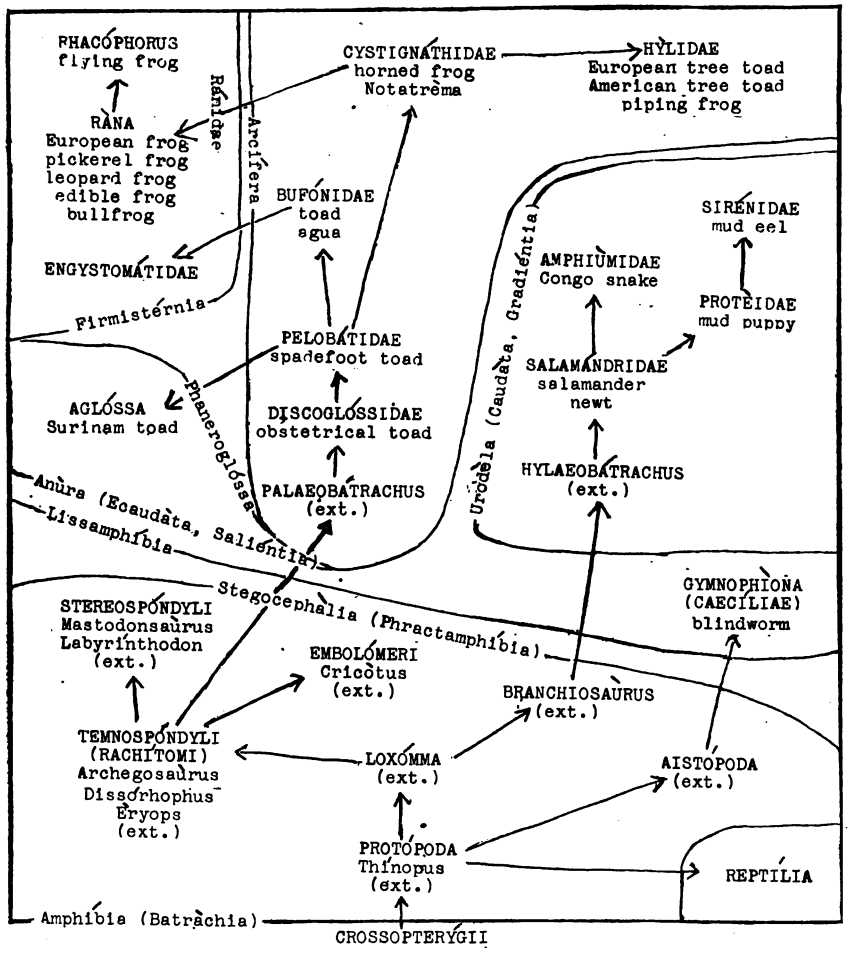

Diagram 27. BATRACHIA (Frog order). It is believed that the fins of fishes, paddling on muddy shores, became feet, that the air-bladder by subdivision became a lung, and that the crossopterygian (fringe-finned) fishes were thus converted into amphibians (living on both; i. e., on both land and water). Polypterus already has a double air-bladder which on occasion it uses as a lung.

Lungs having been developed later than gills, the gills of tadpoles are suppressed when the lungs appear. Toads lay their eggs in water because their ancestors lived there.

The earliest known amphibian, of which only a footprint has been preserved, has been named Thinopus (Shore-foot), and the group to which it belonged Protopoda (First-footed).

The great amphibians are all extinct. Living ones are divided into the Urodela (Visible tails), the Anura (Without tails), and the blind worms. The Urodela walk, the Anura jump. The Anura are divided into the Phaneroglossa (Visible tongues) and the Aglossa (Without tongues), the Surinam toad having no tongue.

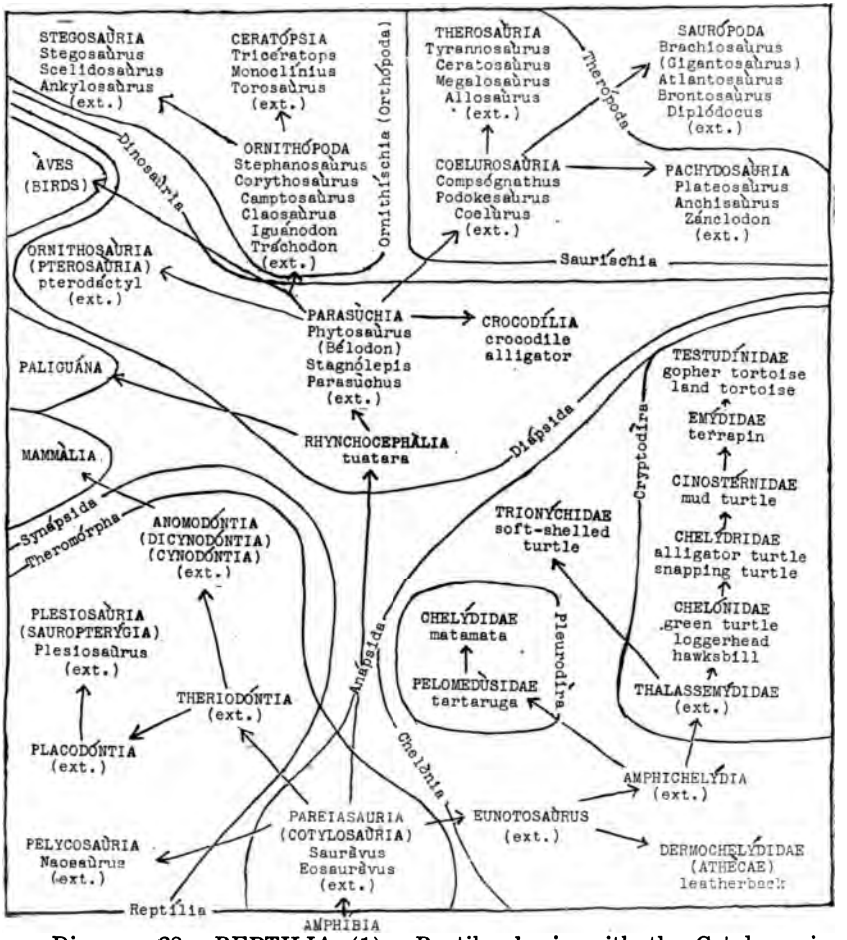

Diagram 28. REPTILIA (1). Reptiles begin with the Cotylosauria, the oldest known member being named Sauravus (Lizard-grandfather). When another was found a little older it was dubbed Eosauravus (Dawn-lizard-grandfather). Should its grandfather be discovered, no doubt the Greek and Latin dictionaries will be equal to the emergency.

Eunotosaurus (Well-backed-lizard), the earliest known reptile with a shell on its back, was the beginning of the turtles.

But the great reptiles, the kings of the ancient world, were the dinosaurs (terrible lizards; the Greek word **saurus**, occurring so many times, meaning lizard. Though not exactly lizards, the name answers the purpose).

The dinosaurs are divided into two groups, the Saurischia (Lizard-hipped) and the Ornithischia (Bird-hipped). The bird-hipped were very close to the birds; indeed some of their tracks in Connecticut were long mistaken for the tracks of birds. The early "bird-hips" separated into two branches, the Stegosauria developing armor for defense, and the Ceratopsia horns for offense.

Gigantosaurus, from the Cretaceous period in what was German East Africa, was reported to be 160 feet long; but the length of the tail was overestimated, and the creature is now identified with Brachiosaurus, which was about 80 feet long. Its enormous body still makes it the largest known animal.

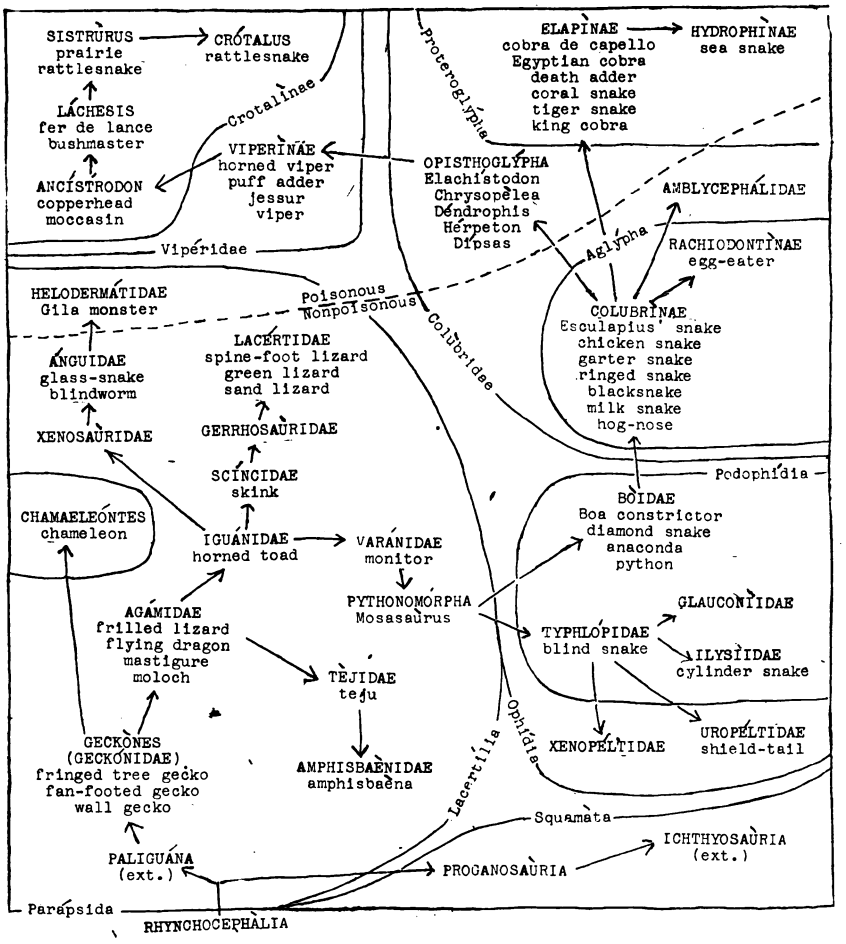

Diagram 29. REPTILIA (2). Squamata (Scaly). These are the geckos, chameleons, lizards, and snakes. Snakes came from lizards, the legs having degenerated until they have entirely disappeared except in the lowest group of snakes, the Podophidia (Footed snakes), which have rudimentary limbs. The boa constrictor still retains the claws of its ancestors with which it is assisted in climbing trees.

It is uncertain which family of lizards gave rise to the snakes. Several families have produced legless forms, as the blind worm, glass snake, and amphisbaena, but these are not true snakes. True snakes have also lost their eyelids. Haeckel derives snakes from the Pythonomorpha (Snake-shaped).

Poisonous snakes come from the nonpoisonous, the poison being a special development of the saliva to numb the prey. Rattlesnakes were developed from the bushmaster of South America, and as they have never been able to cross the sea there are no rattlesnakes in the Old World. Many islands are without snakes because none could get there.

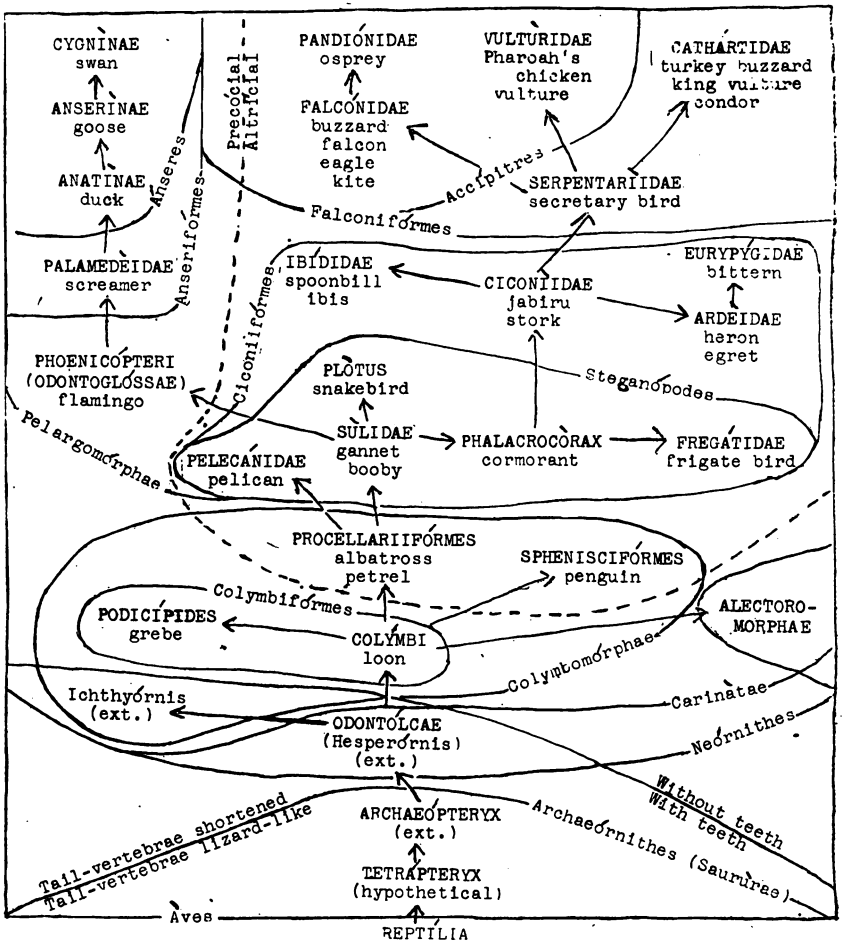

Diagram 30. BIRDS (1). The oldest known bird is the Archaeopteryx (Ancient wing) of the Jurassic period in Bavaria. It was of about the size of a pigeon, and its reptilian character was very marked. It had a lizard-like tail as long as the body with feathers on each vertebra, and reptilian teeth, but no beak had been developed. Its wings were evidently capable of flight.

Between true reptiles and Archaeopteryx there is a wide gap that for the present can be bridged only by conjecture. There is no doubt that scales were turned into feathers, for even now scales begin where the feathers leave off. It is supposed that certain reptiles akin to the early dinosaurs, living in trees, acquired first the power of gliding, being assisted by their scales, which in course of time became feathers, on both the fore and the hind legs. This would make a four-winged bird which has been named Tetrapteryx (Four-winged). As the feathers used in gliding became more efficient on the fore legs those on the hind legs gradually degenerated, and the business of flying was turned over to the fore legs. Certain rudimentary quill-feathers on the hind legs of the young of the pigeon and of other birds, wholly useless to the modern bird, are believed to represent the gliding feathers of Tetrapteryx.

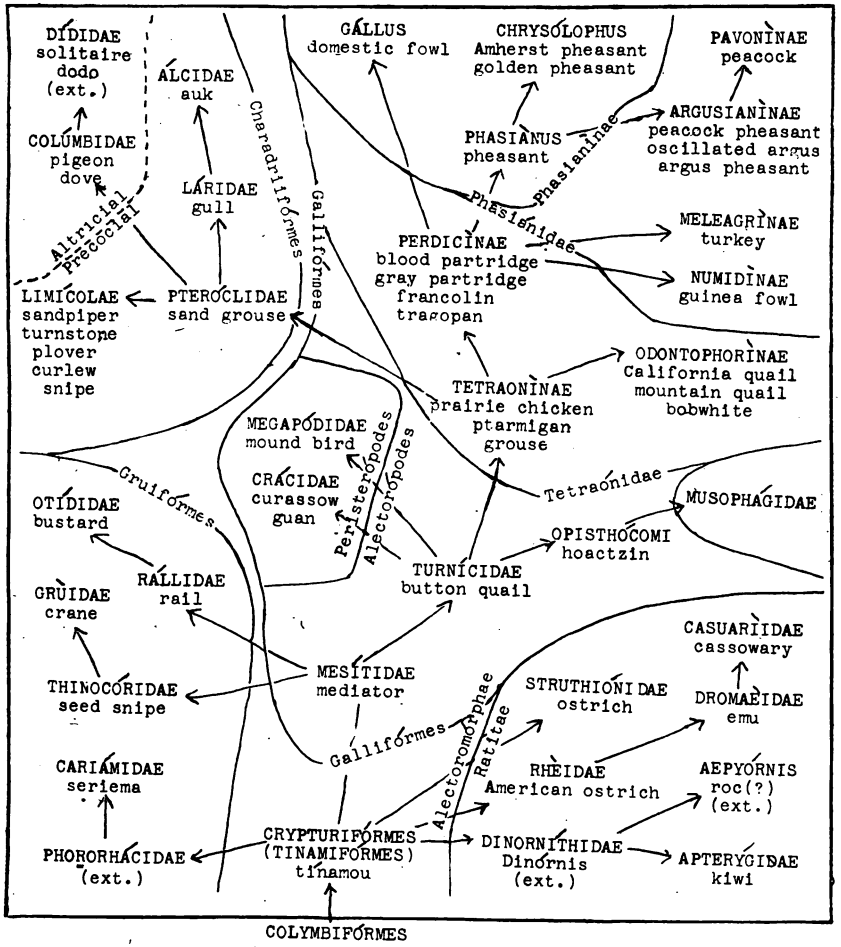

Diagram 31. BIRDS (2). Alectoromorphae (Greek, Rooster-shaped). This great group comprises the Tinamiformes (Latin Tinamou-shaped), the Gruiformes (Crane-shaped), the Galliformes (this is Latin and also means Rooster-shaped), and the Charadriiformes (Plover-shaped).

The curassows and mound birds, constituting the Peristeropodes (Pigeon-footed), acquired the pigeon foot, but failed to make the other necessary changes and never became pigeons.

RATITAE (Rafted). Birds are like vessels on the water; most of them have keels. Those that do not have keels are mere rafts. The keel of a bird is that prominent ridge on the breastbone that has so much meat (wing-muscle) on it. Such birds are the Carinatae (Keeled). The ostrich and its relatives have no keels, and scarcely need wing-muscles, as they do not fly.

It is generally believed that the Ratitae are descended from flying birds, and they are usually connected with the tinamous; but the feathers are peculiar, and it is possible that, instead of having lost the power of flight, they represent an early branch of the birds that never acquired it.

The Dinornis (Terrible bird) or moa of New Zealand was 12 feet high, and the Aepyornis (High bird) of Madagascar (supposed to be the original of the "roc" of the Arabian Nights), was even larger, and its egg was 13 inches long—the largest egg known.

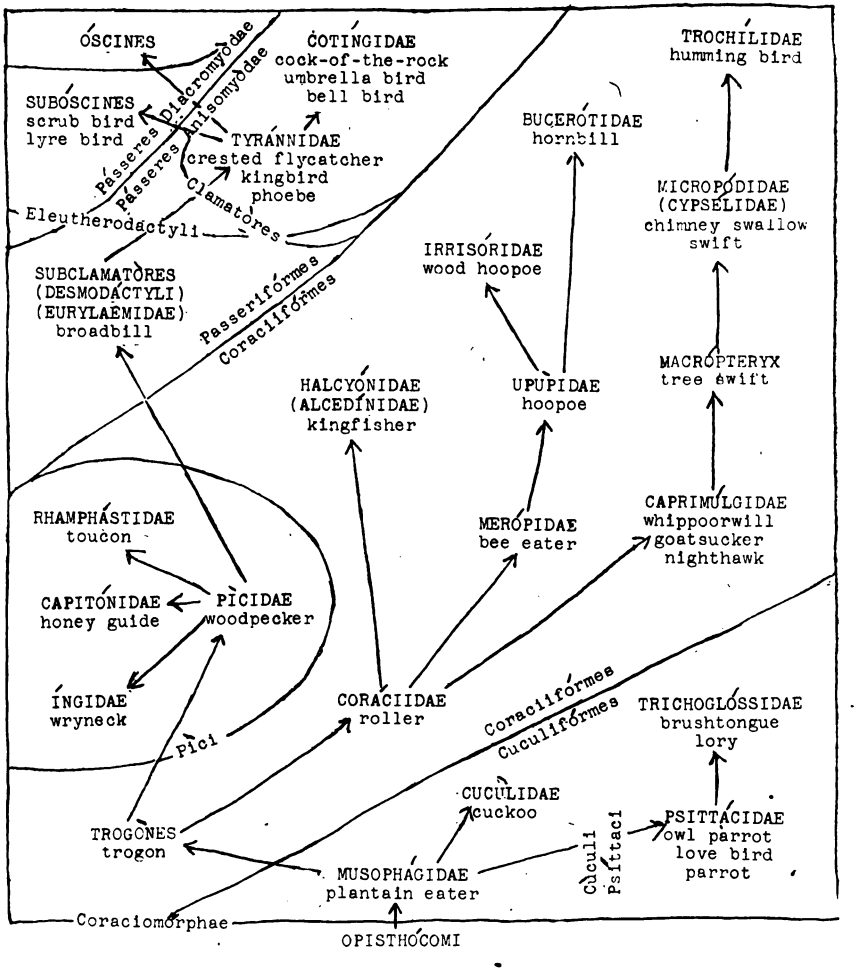

Diagram 32. BIRDS (3). The plantain eaters, which ought to be called banana eaters, for the plantain they eat is a kind of banana, are the ancestors of the cuckoos and parrots, and also of the trogons, from which have come the owls, rollers, and woodpeckers.

The Caprimulgidae are the Goatsucker family. When the ancient shepherds failed to get as much milk from their goats as expected they said that these birds, active about milking time, had sucked the goats. The superstition spread, and the birds are called goatsuckers in many languages.

Humming birds came from the swifts, often miscalled "swallows." It is "chimney swift," not "chimney swallow." Swallows are higher up and belong to the Oscines.

Woodpeckers lead to the kingbirds, and the kingbirds to the Oscines, the highest of all.

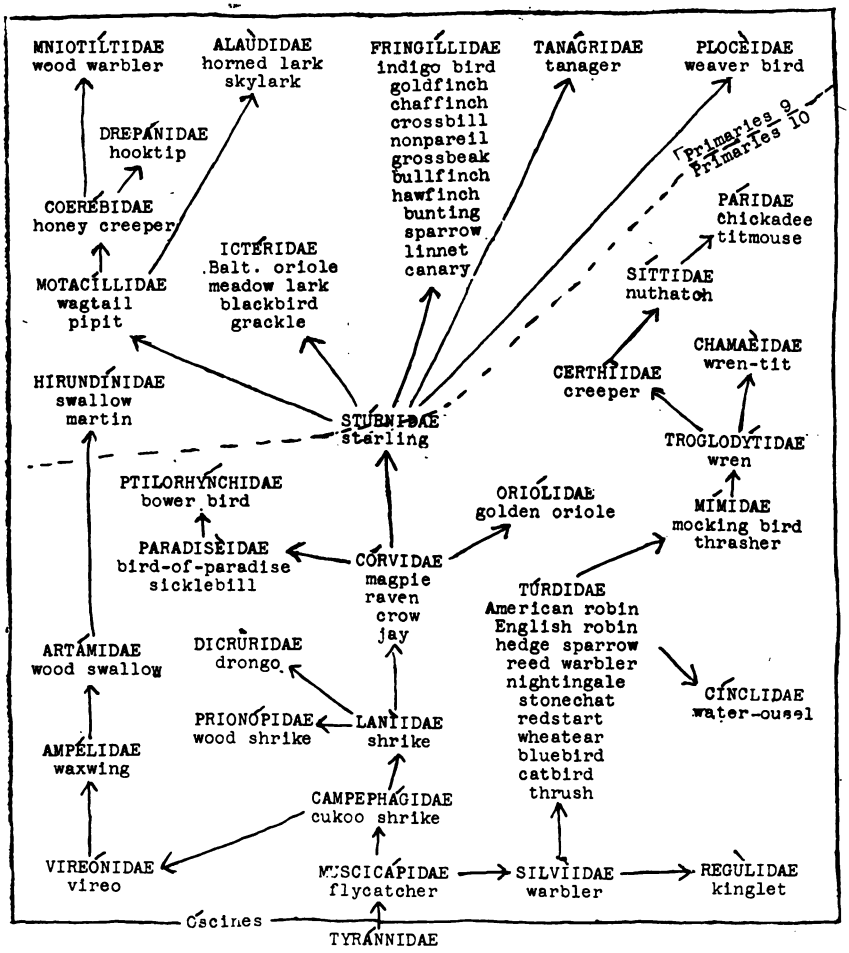

Diagram 33. BIRDS (4). The Oscines or singing birds are the grand culmination of bird life. Some of them do not sing, and some do not sing sweetly, but those that do have added not a little to the happiness of mankind.

Birds of paradise come from the Crow family. East Indian traders who first brought the skins of these wonderful birds to Europe declared that the birds had no legs, that they fed on the dews of heaven and rested at night hanging by their tail-feathers to the branches of trees. And so Linnaeus, who of course did not believe the story, nevertheless embalmed it in the bird's name, Paradisea apoda (Legless paradisean). The natives had cut off the legs before exporting the skins.

The starlings are probably the ancestors of the Finch family, which includes the canary, as well as of several other families, and are very close to the Icteridae.

Mocking birds connect the thrushes with the wrens.

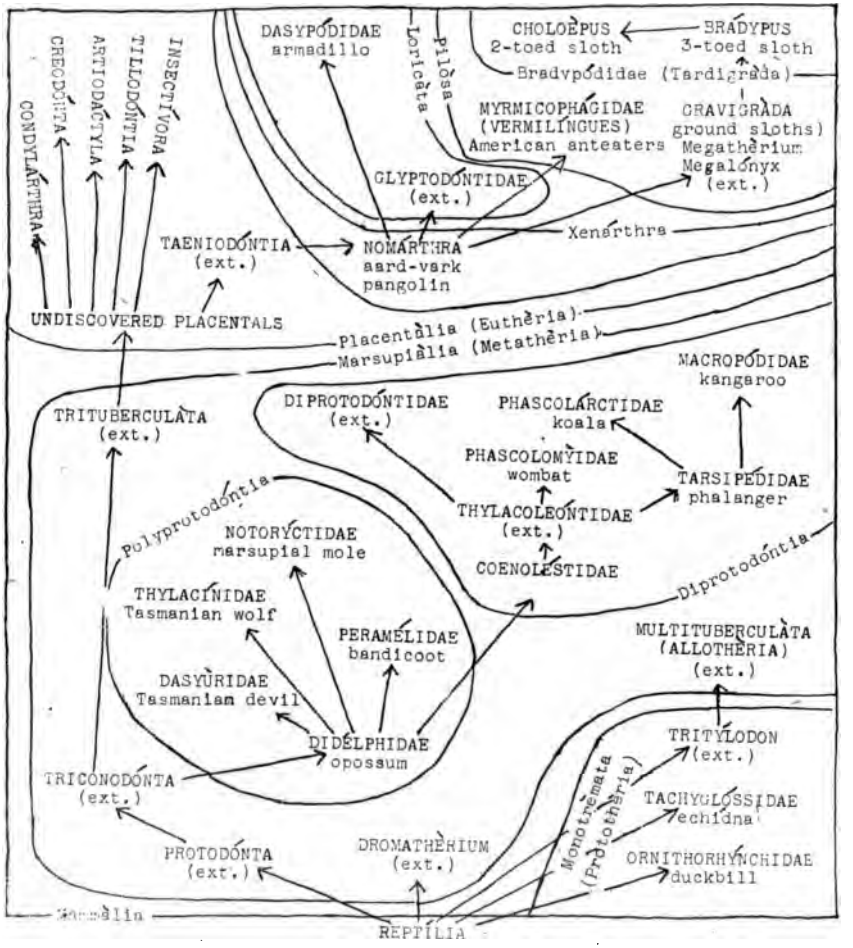

Diagram 34. MAMMALIA (Having breasts). This class includes man and all the higher animals—all that suckle their young—and falls into three groups: (1) Monotremes, as the duckbill, a bird-beaked, fur-bearing animal that lays eggs; (2) Marsupials, which carry their young in a pouch after they are born, as the opossum and kangaroo; (3) Placentalia, which include all the rest. The first placentals have not been discovered, but they probably came from the trituberculate marsupials.

EDENTATA (With teeth out). These animals are improperly named, as only a few are without teeth. A number of gigantic forms are extinct. Megatherium (Great beast) was a ground sloth nearly as large as an elephant. Megalonyx (Great claw) was named by Thomas Jefferson from a claw over 7 inches long found in the mountains of Virginia. Having no conception of the evolution and extinction of species, Jefferson supposed the claw to be that of a gigantic species of lion that must be still roaming about somewhere in the mountains. He wrote an article on the subject which was the beginning of palaeontological studies in America.

The plates of the armadillo and the solid shell of the extinct Glyptodon were probably developed from scales similar to those of the pangolin.

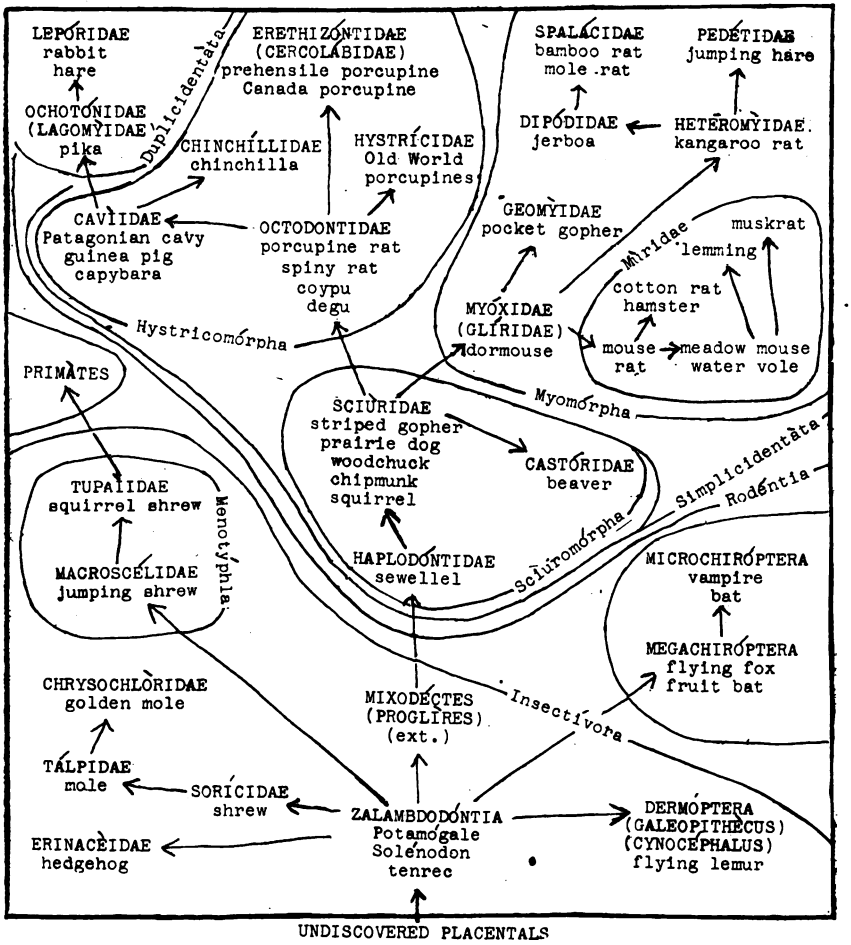

Diagram 35. INSECTIVORA (Insect-eaters). This order begins with the river mole (Potamogale) of West Africa, the Solenodon of the West Indies, and the tenrec of Madagascar, which, on account of its spines, may be considered the beginning of the hedgehogs (not the porcupines, which belong to a higher order). The Tupaioidea, which include the squirrel shrew or pentail of Borneo, are of special interest as the ancestors of the Primates.

CHIROPTERA (Hand-winged; the flying membrane being stretched over the greatly enlarged fingers of the hand). The bats may have come from the flying lemurs, but probably they are another branch of the early Insectivores that developed a flying mechanism. The small bats (Microchiroptera) are descended from the large ones.

RODENTIA (Gnawers). The most primitive rodent now living is the sewellel of the Pacific coast. From the sewellel family came the squirrel family, and from these the beavers; these three families constituting the Sciuromorpha (Squirrel-shaped). This group branched out in two directions, one branch becoming the Myomorpha (Mouse-shaped) and the other the Hystricomorpha (Porcupine-shaped).

From the guinea pig family of the Hystricomorpha came the pikas, the hares, and the rabbits, distinguished from all the rest of the Rodentia by the presence of two sets of front teeth, one behind the other.

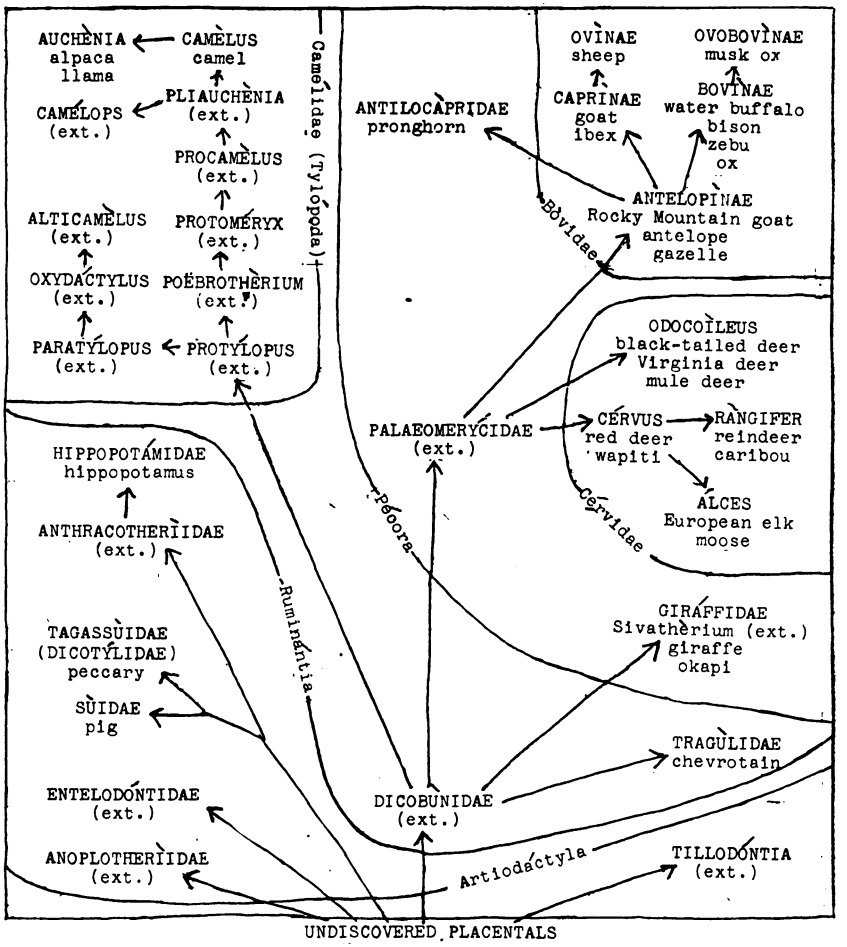

Diagram 36. ARTIODACTYLA (Even-toed). This is one of the groups that come from the undiscovered placentals of Mesozoic times.

The pig and the peccary are closely related, and both are cousins of the hippopotamus (river horse).

A long line of ancestors has been discovered for the camels, which, as ruminants, must have come from the Dichobunidae or some related family.

The Palaeomerycidae had no horns, and when they began to grow them they grew two kinds, one solid and falling off every year (Deer family), the other hollow and permanent (Ox family).

The antelopes, the beginning of the Ox family, took two lines of development, one leading to the ox and musk ox, and the other to goats and sheep.

The okapi, recently discovered in Africa, is a relative of the giraffe, and both are probably descendants of the extinct Sivatherium (Siva's beast) of India, Siva being one of the Hindu gods.

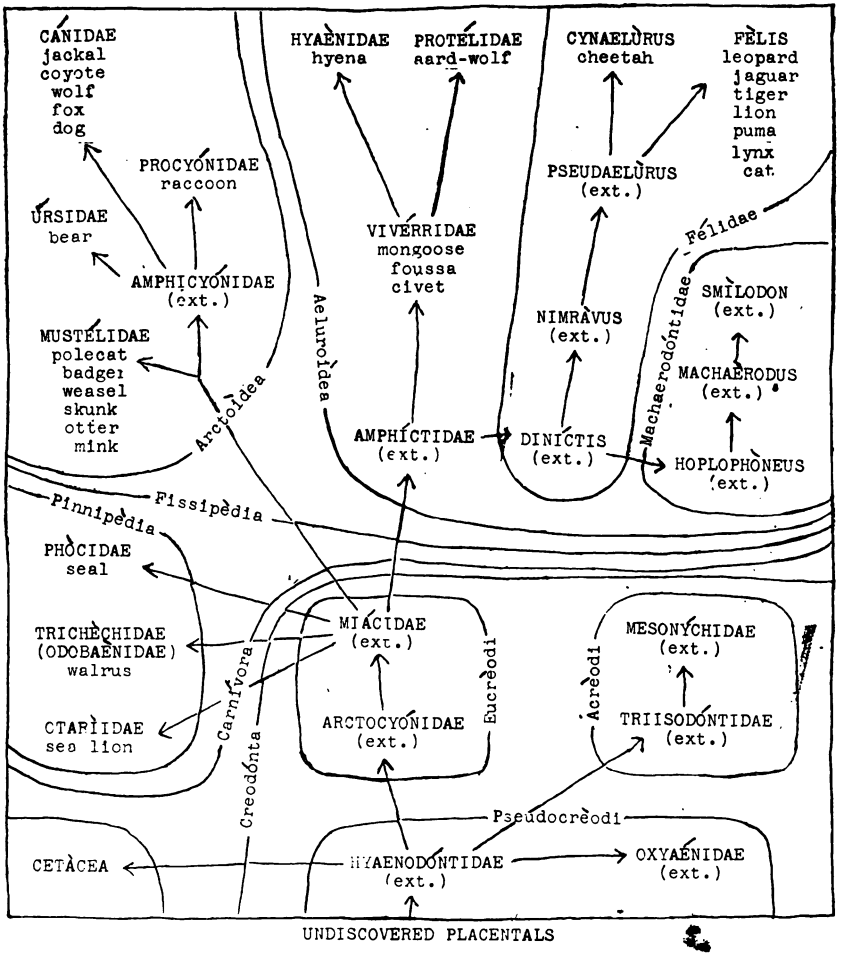

Diagram 37. CARNIVORA (Flesh-eaters). This order includes the Dog family, the Bear family, the Weasel family, the Cat family, and many others, living and extinct. They are descended from the Creodonts, which are sometimes classed with them; "creodont" meaning flesh-toothed, i. e., with teeth suitable for tearing and eating flesh. From the lowest group of the Creodonts came the whales, and from the highest came the sea lion, walrus, and seal, constituting the Pinnipedia (Feather-footed, i. e., fin-footed), and the Arctoidea (Bear superfamily) and the Aeluriodea (Cat superfamily), constituting the group Fissipedia (Split-footed, i. e., with toes). Of course the former became fin-footed by the growing together of the toes of their ancestors as they became accustomed to living in the water.

The saber-toothed tiger and its entire family are extinct.

Nimrod "was a might hunter before the Lord." Gen. x. 8. Some palaeontologist has humorously named one of the ancestors of the cat Nimravus (Nimrod's grandfather)!

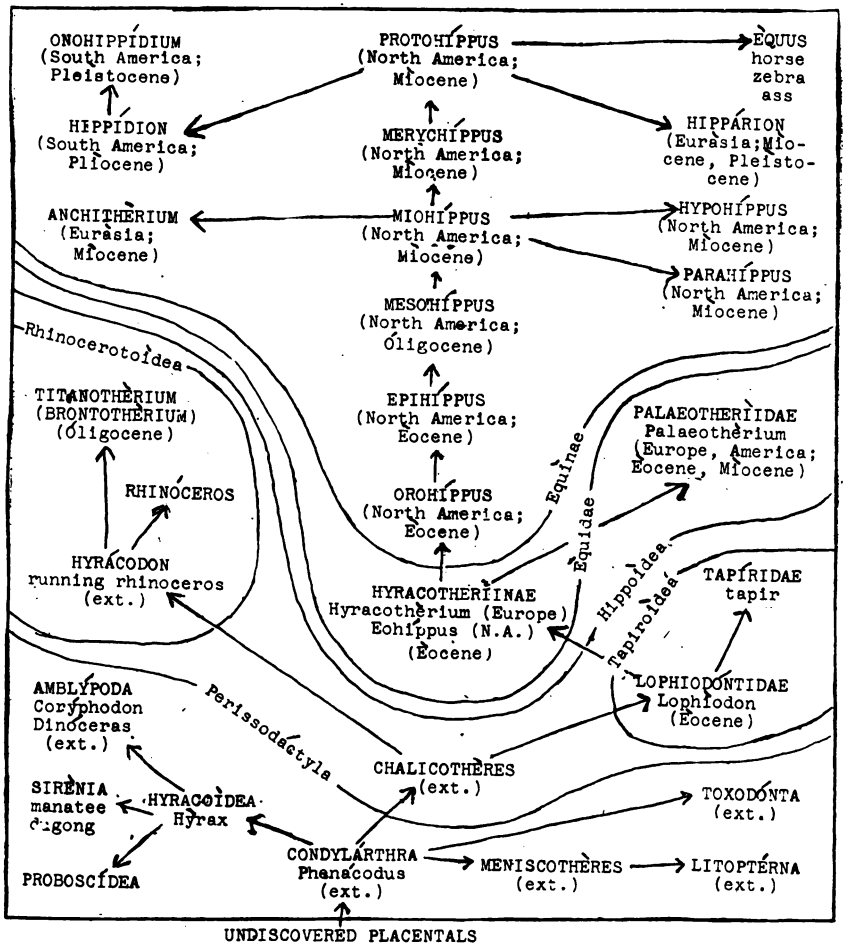

Diagram 38. CONDYLARTHRA (Knuckle-jointed). These were the ancestors of elephants, horses, sea-cows, tapirs, and rhinoceroses, constituting the Perissodactyla (Odd-toed).

The true horse, Equus, originated in North America in the Pliocene period, emigrated to South America, and from Alaska passed to Asia and thereafter died out in the New World and was only reintroduced after the discovery of America by Columbus.

But back of the true horses stands a long line of ancestors connecting them with the five-toed animals. Beginning with Eohippus (Dawn horse) of North America (or Hyracotherium of Europe, which was very similar), which had four toes in front and three behind, and was about the size of a fox, these hippuses (the Greek word **hippus** means horse) increased in size and lost one outer toe after another until only one was left, the central toe, the nail of which had grown into a hoof.

The evolution of the horse was so clearly proved by a closely connected series of fossils that Huxley, who first brought the subject of evolution prominently before the American public, took the fossil horses as the subject of his lectures in New York.

The bones of about forty species of hippuses have now been found in America.

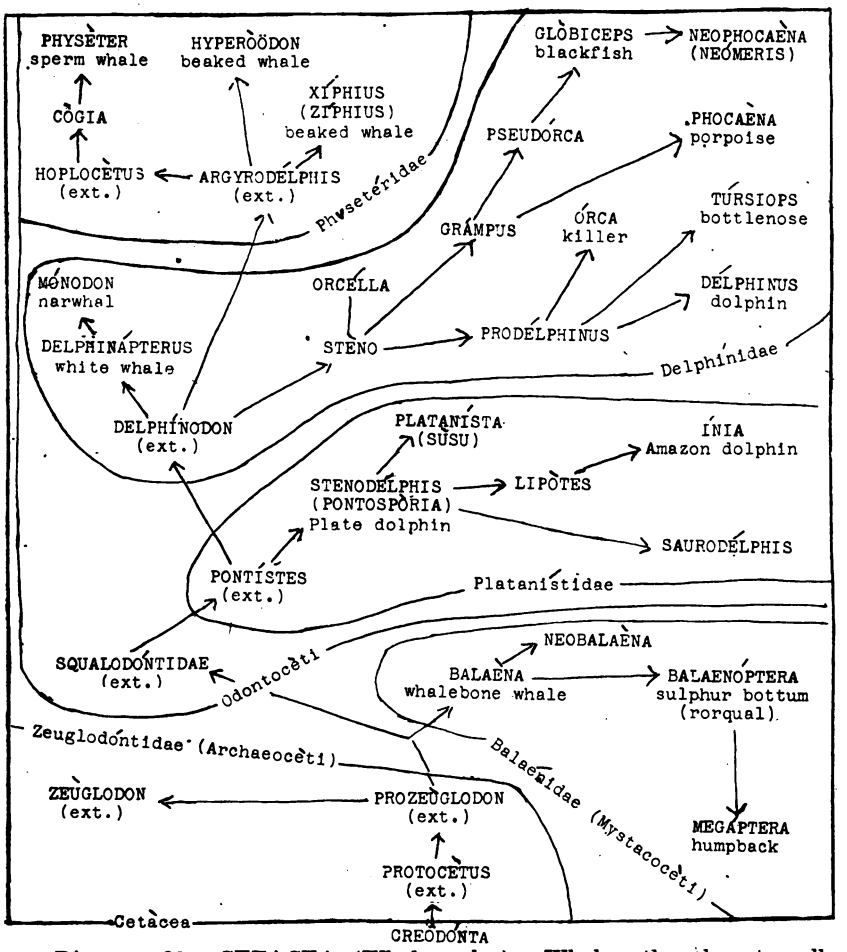

Diagram 39. CETACEA (Whale order). Whales, though outwardly resembling fishes, are mammals, and suckle their young. The earliest whales so closely resemble the Creodonts that there can be no doubt that they came from Creodonts that changed their habitat from land to water. The legs are gone, but remnants of the hip-bones of the Creodonts still linger in the whales.

Whales are divided into three groups: Archaeoceti (Ancient whales), Mystacoceti (Mustache whales), and Odontoceti (Toothed whales). In the mustache whales the whalebone hangs down at the sides of the mouth.

One of the most remarkable members of this order is the narwhal. The male carries a long, twisted horn (developed from a tusk), apparently for the purpose of fighting. Sometimes the male has two horns parallel to one another, but normally one is rudimentary. The females also have two rudimentary horns that do not break through the gums. As the males became chivalrous and did the fighting for the females the latter ceased to grow the horns.

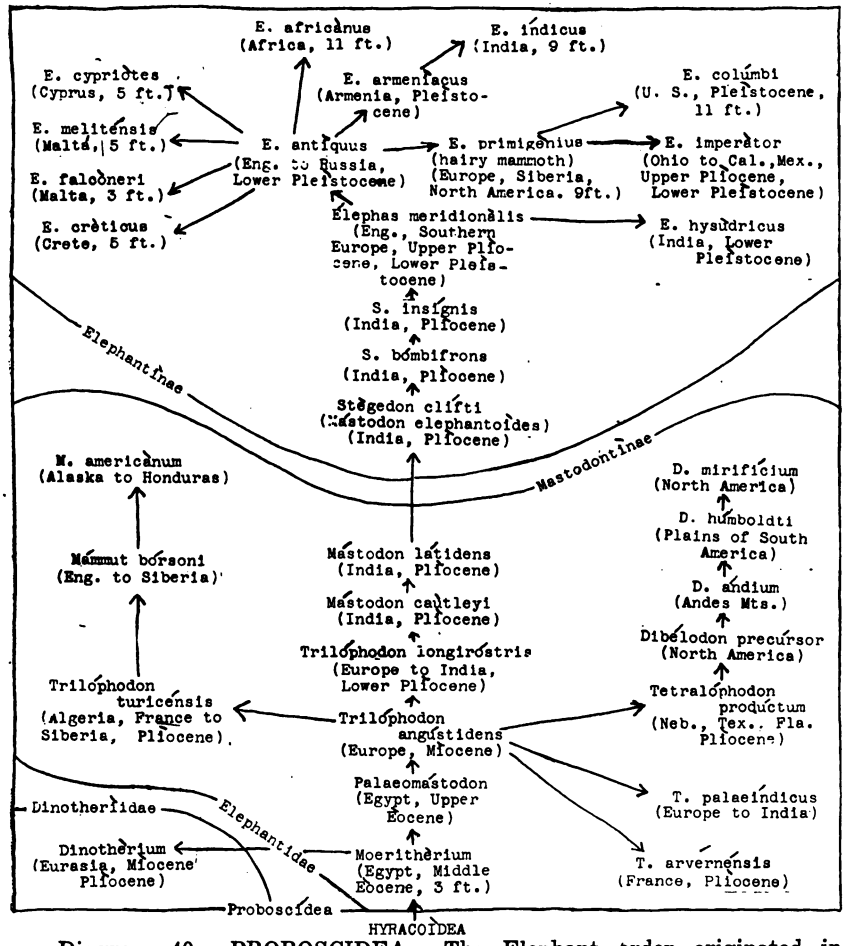

Diagram 40. PROBOSCIDEA. The Elephant order originated in Egypt in the Eocene period, the earliest known form being found near the ancient Lake Moeris, whence the name Moeritherium (Moeris' beast). The tusks and proboscis had barely started on their long and wonderful course of development, the tusks being as yet undecided whether to turn up and be mastodons and elephants or down and be dinotheriums.

Tetralophodon passed from Siberia to Alaska and became the progenitor of the Dibelodons of North and South America.

The Mammuts (generally called mastodons) took the same route, and their bones are found from Alaska to Honduras.

Still later the hairy mammoth of Siberia, which grew a heavy coat of hair for protection as the Ice age came on, and whose remains—flesh, bones, and hair—are preserved in the ice to the present day, tried its fortunes in the New World, and was probably the ancestor of Columbus' elephant and the Imperator.

Elephants marooned on the islands of the Mediterranean were dwarfed (as were horses on the Shetland Isles) by the hard conditions of life in their restricted environment.

Of all the mastodons and elephants known to former ages, only two elephants, the African and the Indian, survive; the latter being the species commonly exhibited in circuses.

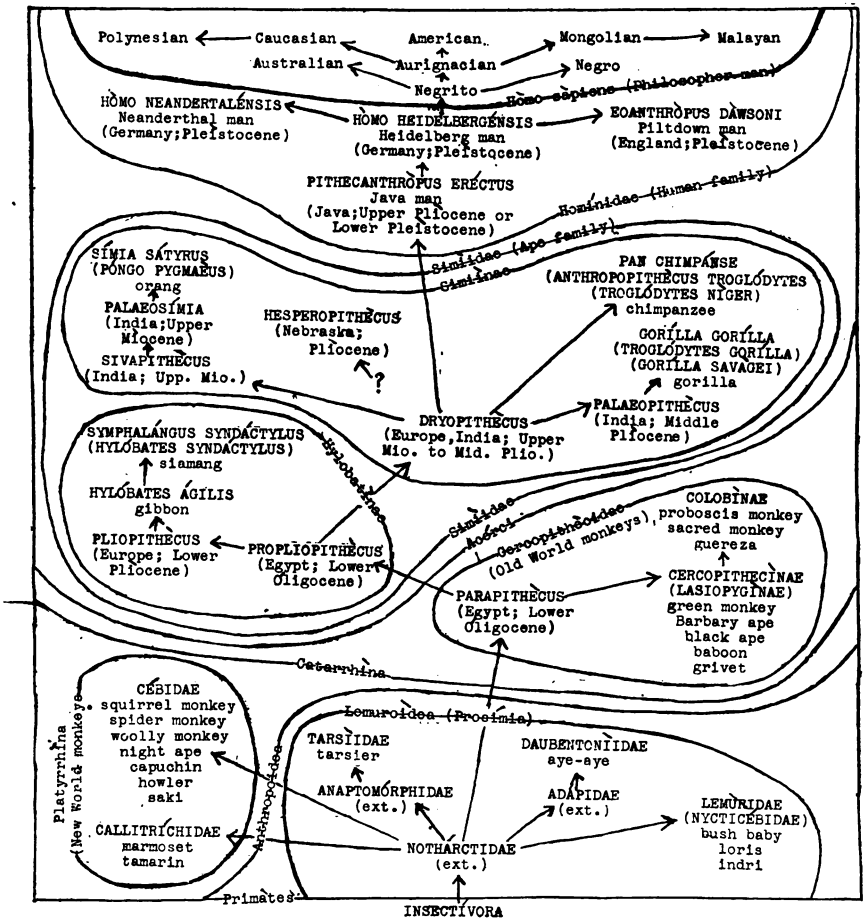

Diagram 41. PRIMATES (Firsts). The Primates are first if one begins at the top, as was formerly the custom, but last if one begins at the bottom.

The Primates include man and the apes, monkeys, and lemurs.

Homo sapiens, the present species of man, is probably the only species that has ever been intellectual enough to produce philosophers.

It is doubtful whether Neanderthal man and Piltdown man were direct descendants of Heidelberg man. Perhaps they are offshoots from a point on the line nearer to Pithecanthropus.

There is no primate now living that can be regarded as in the direct line of human descent. Dryopithecus, Propliopithecus, Parapithecus, and the Notharctidae are all extinct.

The Java man was so near the border line between man and the apes that his classification is doubtful, though the tendency is to place him on the human side.

Hesperopithecus, of which only two teeth have been discovered, is still more uncertain, but the name signifies "western ape." He may have been a "Hesperanthropus" (western man).

Man was differentiated from the apes in the Pliocene, or possibly as early as the Miocene, period.

While the apes and men together constitute the group Acerci (without tails), tailed apes and even tailed men have appeared as reversions to the ancestral type. The human body is full of proofs that it was derived from lower forms of life. As the baby ape is carried about on its mother's back, clinging tightly to her hair, so the human baby, inheriting that powerful but now useless grip, can support its own weight from its hands, and still loves to pull its mother's hair and its father's whiskers.

As mother love grew stronger, prompting tenderer care of the child, the child grew more helpless and the period of infancy was prolonged. Far from being a detriment, however, this long period of infancy laid the foundation for that intellectual development which finally lifted man above the apes. Surely love is the greatest thing in the world!

Such a view of the origin of man, founded as it is upon the facts of science, adds to his dignity and suggests untold future possibilities.

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